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THE MUSK-RATS AS BUILDERS AND MINERS.*

BY J. K. LORD, F.Z.S.

(*With a Coloured Plate.*)

The genus Fiber has hitherto been based on a solitary species, the well-known musk-rat—*Fiber zibethicus* of zoologists—the musquash of Canadian trappers and fur traders, the ooklak of the inland Indians west of the Rocky Mountains. Strictly American mammals, musk-rats, true to their native proclivities, are habitual wanderers, regardless of even "Squatter's Pre-emptive Law," unscrupulously seize on "new locations" that best befit their tastes and requirements.

A summer travelling party of musk-rats, on discovering a desirable spot for a settlement, at once appropriate it. One species sets to work and erects neat little dwellings, that are always placed in the water; the building materials fringe the pool, fixed on as the village site. The other species, *diggers* by profession, scorn the builder's art, and *excavate* houses on the bank of some lazy stream or muddy pool.

The requisite establishments complete, the emigrants settle quietly to the "struggle for existence," and patiently bear as best they can, the ills that musquash, like all other flesh, is heir to.

A happy adaptability to extreme climatal changes, enables the musk-rat to endure the scorching heat of an inter-tropical sun, or the nipping cold of an Arctic winter, with trifling

* Fiber zibethicus, Musk-Rat.

Synonym. — *Castor zibethicus*, "Lin. Syst. Nat.," i., 1766.
Mus. zibethicus, "Gmelin Syst. Nat.," i., 1788.
Myocastor zibethicus, "Kerr's Linnæus," 1792.
Fiber zibethicus, Cuv., R.A.I., 1817, 192.
Lemmus zibethicus, "Fischer Synop.," 1829, 289.
Ondatra zibethicus, "Waterhouse Mag. Nat. Hist.," iii., 1839, 594.
Musk Beaver, "Pennant's Arct. Zool."
Musquash, Wach-usk of the Cres and Hurms (the animal that sits on the ice in a round form).

Nov. Sp.—*Fiber osoyoosensis* (Lord), "Proc. Zool. Soc.," London, 1863.

inconvenience either to its health or happiness. Throughout the length and breadth of Canada—tenanting the shoals of its countless lakes, the banks of its many rivers, the oozy swamps and muddy, stagnant pools—musk-rats are always to be found. Away into the trackless wastes of the Hudson's Bay Company; by the lone, still ponds scattered over the sunny prairies, or hid neath the shadows of the lofty pines; in dark, miry wastes, amid fungoid growths, sedge plants, and perpetual decay; along the banks of tortuous rivers, from their sources—mere mountain burns, trickling down the craggy sides of the Rocky Mountains—to their mingled exit into the Atlantic, as the great St. Lawrence;—musk-rats live, thrive, and multiply. Cross the snow-clad heights of the Rocky Mountains, and descend their western slopes, through hotter lands, to the shores of the Pacific; from the Rio-Grande to the desolate regions of Arctic America; through fertile California; grassy, flower-decked Oregon; Washington Territory, with its deserts and mountains; and the densely-timbered wilds of British Columbia, to its junction with Russian America; on rocky Vancouver Island, as well as every island of any size in the Gulf of Georgia;—musk-rats have found their way, built, and burrowed. It was once supposed, that the musk-rat had made its way to the Asiatic side of Behring's Straits, but there can be but little doubt the skins obtained from Kamschatka and Tschucktchis are traded, or bartered, from native tribes living on the American shores.

There are many structural points of similarity betwixt the musk-rats and *Arvicolas*, or "field-mice;" still the peculiarly formed feet, flattened tail, much larger size, and singularities of habit in the former, distinctly separates the two genera. Indeed, the musk-rat seems to fill a gap, as it were, between the "field-mice" (*Arvicolinæ*) and the porcupines (*Hystricidæ*). The sub-family (*Casterinæ*), which the famed beaver represents, connects the squirrels and marmots (*Sciurissæ*), on the one hand, with the gophers (*Geomyinæ*) on the other. The teeth of the musk-rat are of arvicoline type. The first and third molars are longer than the second, the second being wider than either of the other two. The grinding surface of the first molar has two indentations or reentrant angles on each side; the second, two outside and one inside; the third, three outside and two inside. The first and third grinders have five prisms or projections on their surfaces, the second four. The loops of enamel extending across the tooth, and joining the enamel that encases the surface, completely isolates the patches of dentine; thus a mill-stone is formed by this most simple contrivance, that improves in grinding power the more it is

worked, and never needs roughing with the stone-cutter's hammer.

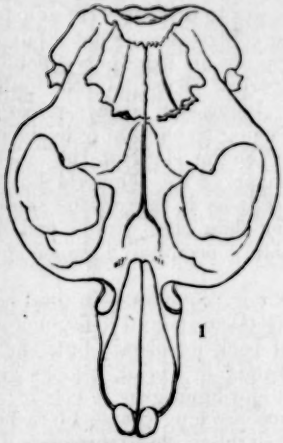
In the lower jaw the first molar is much larger than the second and third, which are about equal in length and width. The first having five indentations inside and four outside. The other grinders have each two on either side; the angles are alternate. The upper cutting, or incisor teeth, are broader than the lower, plane in front, but bevelled off at the outside edges, the lower being more rounded away than are the upper. Like the teeth of all the rodents, they are admirably constructed chisels, that by a simple arrangement of hard and softer material, sharpen themselves, the cutting edges becoming keener in proportion to the density of the material gnawed. The musk-rat's mouth is truly a marvellous mill, worked by machinery that needs neither steam or water-power to drive it. Its millstones, by the side of which man's best contrivance is but a bungle—never wear smooth, or deteriorate in grinding capabilities, however hard the "miller" works. To supply the mill are admirable nippers that never blunt, and always remain the same length, wear and growth being so admirably balanced.

A very marked peculiarity in the skull of the musk-rat (*vide* woodcut) is the curious shape of the temporal bone; so compressed is it betwixt the orbits as to narrow the skull into a mere isthmus, not at all wider than the extreme end of the muzzle. Parietals very small; occipital foramen nearly circular.

Fiber osoyoosensis, Lord, sp. nov. *Sp.char.*—In total length 3¼ inches shorter than *Fiber zibethicus* (Cuv.); in general size much smaller. General hue of back jet-black; but, the hair being of two kinds, if viewed from tail to head, it looks grey—the under fur being fine, silky, and light grey in colour; concealing this on the upper surface are long coarse black hairs; the belly and sides somewhat lighter; head broad and depressed; neck indistinct: ear small, upper margin rounded; eye small and black; whiskers long, and composed of about an equal number of white and black hairs; incisors nearly straight, on the external surface orange-yellow.

The thumb of the fore-foot is quite rudimentary; the third claw is considerably longer than the second and fourth. The hind feet are singularly twisted, the inner edges being posterior to the outer. This simple modification of position, gives the animal immense power in swimming. The feet are then bent towards each other; in the backward stroke, the full expanse of the flat soles pushes against the water, sending the swimmer forwards; in the forward stroke the feet are "feathered," like rowers feather an oar, passing through the water edge on, offers the least possible resistance. The claws

on the hind feet are small, compressed, and but slightly curved. The skin covering the under surfaces of the feet is black, wrinkled, perfectly naked, and keenly sensitive to tactile impressions. A distinct *web* joins the digits for about half their length; the upper parts of the feet, are clothed with short lustrous hairs, terminating at the sides in a fringe of stiff bristles, which increase the surface, and give additional force in swimming. Tail nearly as long as the body without the head, cylindrical at the base, then *flattened* to the point. The tail curves somewhat to a sickle shape; being readily bendable towards the belly, its point can be made to touch the inferior surface of its base; in this position it is almost circular, like a



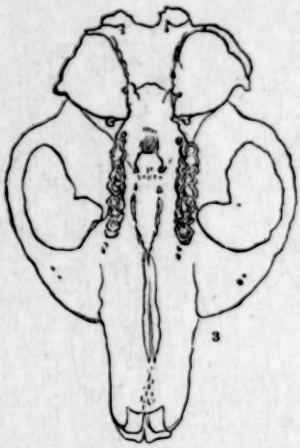
Fiber Zibethicus.

Fiber Osoyoosensis.

hoop. This is a highly important arrangement, indispensable to the musk-rat. A more perfect rudder was never designed than is this flexible tail. If swimming when freighted, and a stiff breeze curls the water into miniature waves, the musk-rat drops its tail, and bending it more or less according as it needs extra steering power, guides itself straight for the desired haven. In calm weather and smooth water the rudder is carried horizontally, and a slight lateral motion close to the surface, suffices to guide the living ship. It is worth while to note, *en passant*, how differently the beaver's *rudder* is built, as compared with that of the musk-rat's—a difference easily accounted for when we know their respective habits. The

beaver never uses its *tail* as a *trowel*, and has no more idea of "lath and plaster" than a hippopotamus has of a polka. This story is a myth, and the sooner the absurd *fables* of plastering, and "using the wondrous tail as a trowel," are sponged from out all books on natural history the better.

The beaver, with a heavy log of green timber (that would sink like a stone if free) clasped between its fore-legs, swims for its house. The counterpoise to this overweight at the bows is the downward pressure of the flat tail on the water, *flattened* more horizontally than the musk-rat's. Indeed, the tail of the beaver is much like an ox-tongue in shape. The musk-rat, conveying such materials through the water as are light,



Fiber Zibethicus.

Fiber Osoyoosensis.

needs *only* powerful rudder-power, having no forward weight to counterbalance. The tail is covered with small hexagonal scales, a few long, coarse hairs irregularly scattered over it. The skull differs from *Fiber zibethicus* in being much smaller, $2\frac{1}{8}$ inches in length, $1\frac{1}{6}$ inch in width, very much shorter from the anterior molar to incisors; nasal bones much more rounded at their posterior ends, the superior outline less curved; postorbital process not nearly so much developed; the cranial portion of the skull in its upper outline is much less concave, and smoother; superior outline of occipital bone not so prominent or strong; incisors shorter and much straighter; molars much smaller, but in general outline similar.

And now I must ask my readers to accompany me, in imagination, to the Osoyoos Lakes, on the eastern side of the Cascade mountains, where my attention was first directed to the rush-building rat, as being distinct in species from the *one* that burrows in the mud banks. The specific name *osoyoosensis* was given in commemoration of the discovery.

This magnificent piece of water is formed by the widening out of the Okanagen river as it passes through a deep valley, walled in by massive piles of rock. The Osoyoos Lake may be defined as one huge lake, or three smaller ones, with equal correctness; as a narrowing in at particular points, gives the appearance of an actual division into separate lakes. The "boundary-line" runs through its centre, so that one half the lake belongs to England (its northern half), the southern to the United States. The shore is sandy, like a sea-beach, and strewn thickly with fresh-water shells along the ripple line, gives it quite a tidal aspect. On either side, a sandy, treeless waste stretches away to the base of the hills, so carpeted with cacti, that grow in small knobs covered with spines, like vegetable porcupines, that walking on it without being shod with the very thickest boots, is to endure indescribable torture, the prickles are so sharp and hard that they slip through ordinary leather like cobbler's awls. I had to tie up both dogs and horses, for the latter, getting the prickly knobs into their heels, kicked and plunged until exhausted. The dogs at once got three or four fast to their feet; when impatiently seizing the vegetable pests, the prickles stuck with like pertinacity to the tongue and cheeks. I have no hesitation in saying a dog must inevitably die from starvation if he ventured to cross this waste alone; once getting the cactus prickles in his mouth, unaided, he could never free himself. A low divide separates this valley from the Similkameen. The water from the lakes eventually finds its way into the Columbia river. If there is an Eden for water birds, Osoyoos Lakes must surely be that favoured spot. At the upper end a perfect forest of tall rushes, six feet in height, afford ducks, grebes, bitterns, and a variety of waders, admirable breeding haunts; safe alike from the prying eyes of birds that prey on their kindred, and savages that devour anything.

The water, alive with fish of many species (permanent residents), becomes during "the season" crowded with lordly salmon like a fashionable watering-place; thus affording a perpetual banquet to birds that devour fishes. The tempting, juicy mollusks, "like turtle," seems palateable to all, be the diners scale-clad or feathered. On one side of this lake is a swamp, in which are numerous pools, some of them deep in the middle, shoal at the sides to a few inches, all alike fringed

with a tall growth of rushes. In these aquatic snuggeries, ducks, literally swarm thick as bees round thorn-blossoms. Here, too, musk-rat houses may be likened to cities rather than villages—the inhabitants, swimming idly about, just diving out of the way if I came too near, reappearing a short distance off, evidently deemed me an impudent intruder. Two were shot, one of which forms the subject of the illustration.

For years I had been in the habit of seeing these rush houses (that I shall presently describe), but took it for granted there existed but *one* species of musk-rat, whose winter quarters was the rush house; its summer residence a tunnel excavated in a mud bank. Sir John Richardson (Fa. Bo. Am.), after describing the "winter huts," goes on to say, "In summer the musquash burrows in the banks of the lakes, making branched canals many yards in extent, and forming its nest in a chamber at the extremity, in which the young are brought forth." Another author writes, "They live in curiously-constructed huts, in a social state during winter; in summer, these creatures wander about in *pairs*, feeding voraciously on herbs and roots." Charleroix adds, "They build cabins, nearly in the form of those of the Beaver, but far from being so well executed; their place of abode is always by the waterside, so that they have no need to build causeways."

Captain John Smith was in all probability the first, who gave any account of the musquash, in a work published in the year 1624. He says, "The musascus is a beast of the form and nature of a water-rat, but many of them smell exceedingly strong of musk.

"We are not, however, aware that these nests are made use of by the musk-rat in spring for the purpose of rearing its young; we believe these animals *always* for that purpose resort to holes in the sides of ponds, sluggish streams, or dykes."—Aud. and Bach.

Seated on a sandy knoll, I contemplated, measured, and began to skin my prize. It occurred to me that there were no mud banks near, into which these rats could burrow, and according to the statement of the authorities, at this very time, they ought to have been in their *summer* holes.

My first proceeding was to hunt carefully round the lake to discover, if possible, some evidence of a burrow—not a trace of such could I find; next the rush houses underwent a rigid scrutiny. In each musk-rats were living, and more than this, whole *families* had clearly resided in the several mansions for a very long time. I now felt convinced there must be two distinct *species*, one a *miner*, the other a *builder;* and further, that the two species had been clashed together by observers, under the supposition that they changed quarters, in accordance with the

seasons. The next thing was to prove my supposition, based on correct data.

Tents were soon after struck, and the lake, with all its living treasures, abandoned to nature and the red man.

We must take up our story at Fort Colville, one of the earliest trading posts of the Hudson's Bay Company, situated on a gravelly plateau, close to the Kettle Falls, on the Columbia river, about a thousand miles from the sea.

The two weary winters passed in this solitary spot were cold enough to satisfy an Esquimaux, the temperature often as low as thirty and thirty-two degrees below zero; with deep snow covering the ground for full six months of the twelve. Through the gravelly valley leading from the Fort to the hills wound a sluggish muddy stream, with deep banks on either side, in which dwelt whole colonies of musquash. About a mile and a-half from the stream, divided from it by a steep ridge of rocks was a sedgy flat, surrounding a deep, quiet pool, so overshadowed and shut in by a brake of bulrushes, as to be hidden until its margin—reached by wading and cutting a trail through the reedy fringe—revealed its water, and a city of musquash-houses scattered like hay-cocks over the entire surface.

In the bright, glowing sunshine of the mid-summer, I carefully watched the stream and pool, fully satisfying myself that both localities were densely populated; and, further, that "builders" and "miners" were blessed with infant workers, born, some in the rush dwellings, others in the nurseries of the mud tunnels. So far, so good, nothing more could be done until winter. On carefully comparing several of the musk-rats shot in the pool, with those brought from Osoyoos lake, I found them to be specifically alike, but differing most markedly from the rats inhabiting the Colville stream; others procured from very distant mud banks, east and west of the Cascade Mountains tallied exactly with these and each other, as did a series of rush-building-rats from widely-separated localities. Up to this point, I had proved that both holes and lodges were occupied in *July*, and the *rats* inhabiting them differed in several disinctive characters always constant, though extended over a series of specimens, from remote and proximate districts.

The furs clothing the two species (as I now venture to call them) seemed to my mind designedly coloured to facilitate concealment. The mud-rat's reddish, rusty brown suit closely resembled the furruginous tint peculiar to the gravelly soils prevailing in the north-west, and its habit is, when frightened, to dive, or if under water, to at once descend to the bottom, there to stir up the mud with all its might. In a second, the course of the fugitive is traceable only by clouds of mud rolled

up into the water, like smoke into the air. Thus hid, escape is easy.

In clear water, too, small roadways are distinctly visible in every direction, threading the bottom of the stream like the lines on a map of railways, trails through which they travel to the different landings and doorways.

The *rush-rat's* black jacket is equally in keeping with the still, dark water in which it swims, builds, and enjoys life; or the sombre stalks amidst which it rambles and feeds. I know no prettier sight than that of watching a musk-rat village. As the shadows lengthen, and the mingled sounds of day die imperceptibly away, and—save the whisper of the breeze as it rattles the tall rushes, the muffled cry of the owl soaring over the marsh, the "quack" and "whistle" of the bald-pate (*Mareca amer*), sure herald of coming night, and the throb of invisible wings—no sounds are audible. In this quiet eventide, the entire *rat* population steal out to swim, flirt, quarrel, or feast, as the custom is in musquash society. So like are the swimmers to dark sticks floating on the surface, that save the tiny wake made as they paddle on, the keenest eye can hardly detect the difference. The slightest noise indicative of danger, plunging sounds over the pool as though a heap of stones hurled into the air, were falling into the water like raindrops, warns one the revellers are gone. They soon, however, reappear, some to sit on the domes of their houses in the position of begging dogs, holding between their fore-feet a dainty on which to sup; others to swim ashore, and forage amidst the rushes and sedge-plants, perhaps to be pounced on by the mousing-owl; whilst the remainder seem to have no definite occupation, but swim or dive for sheer enjoyment. I can recal many long evenings spent by some lone pool, watching these industrious little animals; too earnest in my vigils to note passing time, as stars one by one gemmed the sky, and night with silence came down upon the earth.

Winter came all too soon in October, heavy snow, and biting blasts, sent the hybernators to their quarters, the lingering migrants to their southern retreats, the deer to the depths of the forests, the insects, some to their final home, others into torpidity, hid in cleft or cranny.

If previous statements be true, *no* musk-rats will be found tenanting the mud-holes, but all snugly ensconced in rush-mansions in the pool.

On a piercing cold December morning, I waded through the snow to the miner's quarter, my aid and guide, a redskin, equipped with pick, shovel, and spear, to do the digging and capturing; if the musquashes, as I felt convinced was the case, had not abandoned their dwellings. It was

no easy job breaking through the frozen ground; but the Indian warmed to his work, then I took a spell, and so on, until the subterranean galleries were one after the other laid open. No rats; we were not far enough in. At length we, by digging on, came plump upon a large vestibule, and in it, coiled up semi-torpid and stupid, was a family of "miners;" a goodly heap of dry grass and leaves formed an admirable bed. The sleepers were hardly alive to danger, too drowsy to make any attempt at escape. No food was stored, but they lay huddled together for mutual warmth, as pigs do in straw. There were no holes visible through the snow, but several had been dug through the ground, to give, I imagine, admittance to the air.

This was a grand discovery. If like success attend our assault on the builders, my theory will be proven.

The pool was frozen hard enough to have borne ten men, enabling us to walk easily to the rush-houses, which were built in from three to four feet water. I could discover no holes, though quite three feet of dome in each house was clear above the ice. On removing the snow, and tearing open the intertwined rushes, there, rolled together in a grassy nest, as we had found the miners, were many builders, doing their quasi-hybernation. This clearly proved there were two kinds of musk-rats, that differed in habit, size, and colour. The skulls also showing structural variations, left no further doubt. Two species for the future must characterize the genus Fiber, the second being *Fiber osoyoosensis* (*vide* woodcuts).

The number of young produced at a birth varies from four to seven, and it is by no means uncommon for a female to have three litters in a year; and well for the musk-rats is it that nature has given them such powers of increase. Their enemies are legion. Birds of prey are ever watching for them; indeed, it is difficult to save a trapped rat from the feathered banditti, ready on the shortest notice to tear the prisoner from the iron teeth of the trapper's snare.

The robber gang of weasels are untiring foes, hunting the rats night and day on the land and in the water. Their greatest enemy, however, is the trapper, be he red or white man. Five hundred thousand musk-rat skins were at one time annually imported from the Hudson's Bay Company's territories. At the last fur sale in Fenchurch Street, in August, 1865, 93,787 skins of musquash were sold—a small proportion only of the yearly supply. The fur is used for various purposes, the bulk finding its way to foreign markets. The *musk glands* furnish the powerful, pungent odour from whence the animal derives its name, not to my nose the least like commercial musk. In the spring musk-rats really scent the air, and at

this time the tails are taken off the trapped skins, tied in bundles, dried, and eventually sold in the bazaars at Constantinople for ladies, wherewith to perfume their cloths. The two glands are situated close to the base of the tail. Indians, white traders, trappers and settlers alike devour the musk-rat's body. To cook it *secundem artem*, after skinning, the glands should be carefully removed; the body, split and gutted, is skewered on a long, peeled wand, and carefully grilled over a brisk camp-fire.

I recommend it to you, courteous reader, as it was first commended to me by an old trapper. "Stranger, you may bet your boots, rabbit ain't a patch upon toasted squash. You couldn't skeer up a taller kinder fixin if you was to do your darndest."

There are various modes of trapping musquash. If by steel trap, the trap is usually placed on a log, in the rat's water way, about four or five inches below the surface, with a bait suspended over it. In trying to reach this seductive morsel the hind feet are secured in the iron snare, which has a long string and cedar log float attached, to mark its whereabouts, as the prisoner drags it on the muddy bottom of a stream, or the deeper water of the pools.

Others are caught in a kind of figure of 4 trap, but by far the larger number are speared. The food of the musquash is of most varied character; in the summer, grass, roots of marsh plants, the green bark from the young cotton wood trees, and the stalks of succulent vegetation, constitutes their general fare. Though rodents, and in a measure vegetarians, they never refuse flesh if it can be obtained, and rather enjoy at times doing the cannibal. It is no infrequent occurrence for a hungry band to set upon their relative when fast by the legs in a trap, tear it to pieces, then devour the fragments as hounds are wont to rend and eat a fox. Sir J. Richardson tells us they have been known to eat one another in their houses, if unusually hungry, a statement I can quite believe, although it has never been my good or ill fortune to witness a musquash famine. I have often shot a duck that has fallen into the centre of a musk-rat pond; waiting and wishing for a friendly breeze to waft the prize ashore, I observe it moves slowly, propelled by some unseen power; it nears a rush-house, bobs and bobs like a float as a fish tugs impatiently at the bait, then suddenly disappears. Musk-rats are the thieves that dine sumptuously at my expense. River mussels and craw-fish are also largely consumed by the musk-rats. They either crack the shells of the *unios* with their strong teeth, or, taking them on the land, let them remain until, panting for air, the shells are opened, when the rat pounces in and

devours the inmates. Not only are mussels eaten, but all fresh water mollusks share a like fate, if discovered by prowling musk-rats.

It may be as well to say a few words, in conclusion, about their systems of building. The rush-houses are built in from three to four feet water. A solid pier, composed of sticks, rushes, grass, mud, and small stones, is raised from the bottom to a height of some inches above the surface; over this the dome-shaped roof is thrown, made of intertwined rushes, with mud and sticks worked in amongst them; the bed is placed on the centre or pier, and the entrance is invariably beneath the surface of the water. I do not believe this dome is in any degree impervious to water; whenever I have opened a house in summer, it has invariably been wet; and during blazing hot weather it must be a great advantage to the rush-rats, assisting to keep them cool—an advantage equally enjoyed by the "miners," whose houses are always wet in summer. In winter the water freezes, hence cannot wet the insides of the domes or mud galleries. The grass and other material carried in for the winter bed must manifestly get wet in the transport, but rapidly drains and dries when the water solidifies. I do not believe in the possibility of an animal (formed as the musk-rat) making a *waterproof* fabric out of rushes and mud. One thing has always puzzled me in their engineering: how they manage to keep down the materials forming the centre or pillar, preventing light substances from floating until the aggregated weight of stones, mud, wetted rushes, and sodden sticks becomes, *en mass*, specifically heavier than water, is a secret I was never able to discover. They always work at night, hence it is impossible to watch their operations.

The pleasure of describing the habits of these interesting animals must be my excuse for these lengthy notes. A new species, like gold, usually tempts its finder to wander beyond the limits of prudence; if such has been my failing, I crave forgiveness, and conclude with the sentiments of Wordsworth—

> "To the solid ground
> Of nature trusts the mind that builds for aye:
> Convinced that there, there only, she can lay
> Secure foundations."

EXPLANATION OF WOODCUTS.

1. Skull of *Fiber zibethicus* (Cuvier), showing superior surface. 2. Skull of *Fiber osoyoosensis* (Lord), showing superior surface. 3. *Fib. zib.*, inferior surface. 4. *Fib. osoyoos.*, inferior surface. For description, *vide* page 165.

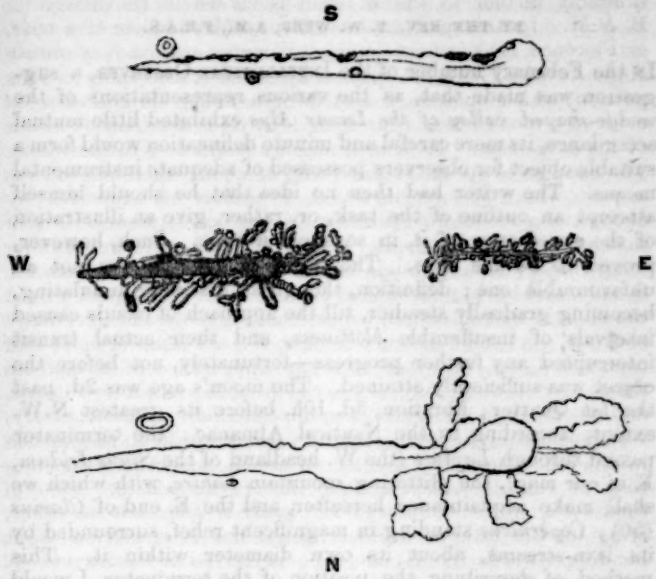
The Coloured Plate represents the Musk-Rats and their Houses.

LUNAR DETAILS. CLUSTERS AND NEBULÆ. CRIMSON STAR. OCCULTATIONS.

BY THE REV. T. W. WEBB, A.M., F.R.A.S.

In the February number of the Intellectual Observer, a suggestion was made that, as the various representations of the *wedge-shaped valley of the Lunar Alps* exhibited little mutual accordance, its more careful and minute delineation would form a suitable object for observers possessed of adequate instrumental means. The writer had then no idea that he should himself attempt an outline of the task, or, rather, give an illustration of the expediency of it, in so short a time. Such, however, proved to be the case. The night of Jan. 25 was not an unfavourable one; definition, though at first very undulating, becoming gradually steadier, till the approach of clouds caused intervals of insufferable *blottiness*, and their actual transit interrupted any further progress—fortunately, not before the object was sufficiently attained. The moon's age was 2d. past the 1st Quarter; libration, 5d. 10h. before its greatest N.W. extent, according to the Nautical Almanac: the terminator passed through *Laplace* (the W. headland of the *Sinus Iridum*, K in our map), the glittering mountain *Lahire*, with which we shall make acquaintance hereafter, and the E. end of *Clavius* (50); *Copernicus* standing in magnificent relief, surrounded by its lava-streams, about its own diameter within it. This method of describing the position of the terminator, I would here remark by the way, is an important adjunct to every lunar observation of value, since it gives the simplest expression of the angle of illumination, and enables it to be compared with any previous or subsequent observations, taken with the same precaution. In this position, employing a very excellent eye-piece, which is formed of two achromatic microscopic object-glasses, and gives on my 7-ft. telescope a power of 212, I found the grey ring *Egede*, noticed in our last number, a very easy object. But my chief attention was directed to the great valley E. of it, which was exhibited with striking distinctness. So far removed from the terminator, the shadows were few and short, but the relief was extremely clear, and quite sufficient to bring out many details in such a way as to show, by mere inspection, how inadequate was the elaborate design of B. & M. Being somewhat pressed for time, and impeded by various hindrances, my first impression was merely to note the data of position, as a guide to more fortunate observers; but the more I gazed at the object, the more charmed I was with the precision of the view, and at last I could not satisfy myself without

getting an outline, which, however rough, I beg to lay before our readers, at the bottom of the accompanying wood-cut, in



juxtaposition with those of Schröter, B. & M., and Lohrmann, standing in the same order with that of their names, and all in their original state as to scale.*

Lunarian students will now have an opportunity of comparing all these representations with the original, and it will be a very desirable result if they should be led to improve upon them all for themselves. My own design, or rather diagram, does not profess to be more than a tolerably correct outline, to which there was no time to add anything like a sufficient amount of shading; it being usually better to attempt no more than what can be carried through consistently, without any occasion for retouching in the absence of the original. The appendages branching out from the E. end of the valley in various directions will be understood to be mountains—a portion of the lunar *Alps*. The whole interior of the valley

* Were it not that wood-engraving cannot afford an exact reproduction of lithography, these designs would be interesting in another respect, as giving an idea of the mode of representation severally adopted by B. & M., and by L. Schröter's designs are on copper-plate.

from end to end was so perfectly defined by its pale grey tint, and its peculiar and almost unbroken evenness, as to admit of no doubt as to its real termination, which is carried considerably further to the E. than is shown in the design of B. & M. In this part, as I saw it, it took the form of a pear, or Florence flask, whose longest diameter made a very obtuse angle to the S. with the general direction of the valley. This portion, which must in reality form a noble amphitheatre, is evidently much better represented by Schröter than by either of his successors. Its length might amount to $\frac{1}{6}$ of the whole. The *neck*, so to speak, of the flask, of about equal length, was a part where it was throttled, especially on the N., by encroaching mountains, till its width was only $\frac{1}{4}$, more or less, of that of the broadest part, W. of it. A low ridge running lengthways was here visible in the bottom, connected with the S. side, and having somewhat the character of a landslip from the cliffs in that direction, which rose ruggedly and irregularly above it. At some distance further W., a similar style of cliff occurred again, but there was no appearance of a landslip there. With these exceptions, the S. side was pretty regular, and not far from straight. The opposite side, on the contrary, was considerably indented, giving various widths to the bottom in different places, the greatest of which, somewhat exceeding that of the *flask*, lay a little E. of the centre. One of Schröter's two little craters was plainly visible; but the other, lying on the interior declivity, could not be traced: a slight bending towards the N. could be perceived at the narrow W. extremity of the valley, but not to the extent indicated by L. Beyond the E. end, a very narrow, irregular gorge continued the line of the S. edge through a lofty part of the *Alps*, widening out at length into the *Mare Imbrium*.

CLUSTERS AND NEBULÆ.

In a recent number of the *Monthly Notices* of the Royal Astronomical Society (Dec. 8, 1865), reference is made to a very curious observation by Professor Krüger, of Helsingfors, on the cluster of λ *Persei*. This astronomer has, with exemplary diligence and perseverance, measured and recorded the positions of 43 stars in the cluster, by referring them to a 9 mag. double star situated among them; and by dividing his results into two half-yearly groups, he has found a difference which seems to indicate a parallax of 0″·66 in the cluster, as though the double star were considerably more distant. This, however, seems improbable, and the Professor has wisely suspended his judgment till he and other observers have more fully investigated the matter. Not being aware of the exist-

ence of any such cluster, and finding that it was not included in the Bedford Catalogue, I resolved to take one of the rare opportunities afforded by the recent most unpropitious season to look for it, when I soon convinced myself that λ was a misprint for χ, and that the cluster referred to must have been the glorious assemblage in the sword-hand of *Perseus*, so well known to every astronomical student. The search, however, was not barren of interest in its own way, and has given us another object for our list.

32. *The Second Cluster in Perseus*, or 61 H VII. If we look from *a Persei* in the direction of *a Aurigæ*, we shall perceive, somewhat nearer to the former, a group of small stars, not very close together, of which the five principal take the shape of a very oblique cross. Of these, the hindermost in diurnal motion, or uppermost at the present season, is a wide pair, distinguishable as such by the naked eye, the mags. being about 5 and 6, and the brighter, which lies to the N., being 18 P. IV. About 1° N. of this star, a little *p*, we shall hit upon our cluster, as a nebulous spot in the finder. Though not one of the more remarkable of its class, it will be a good object for a low power. In the General Catalogue, where it stands No. 820, it is called "very rich, considerably compressed;" its diameter is about 14′ or 15′; the components are from 9 to 12 mags.; and the brighter stars are disposed in curves, and would probably prove easy of measurement. Less than half way from the cluster to 18 P. IV, but somewhat *f*, is an 8 mag. star, remarkable for its fine orange hue. At a little distance *f* the 6 mag. star which lies to the S. of 18 P. IV, but somewhat *n*, we shall see a small pair, grouped with other minuter stars; the brighter of these two, about 8½ mag., may be noticed as possessing a very pale carmine tinge, R⁴ of Smyth's notation. This singular and beautiful quality of stellar light, just perceptible in this instance, and there perhaps not by all eyes, or in all states of the atmosphere, reaches its culminating point in another quarter, in—

HIND'S CRIMSON STAR, *R* LEPORIS.

My search for this celebrated object has been till of late unsuccessful; but having been at length directed to it by means of a diagram kindly furnished me by Mr. Bird, I think it may be detected by careful sweeping, in attending to the following instructions. As far *sf* the Great Nebula in *Orion*, as *Rigel* is *sp*, we shall see *κ*, a conspicuous 3 mag. star, representing the *f* knee of the giant. Draw a line from this to *Rigel;* then a line of nearly equal length dropped from *Rigel* perpendicular to the last will point out *μ Leporis*, marked

5 mag. in the S. D. U. K. Map, but evidently considerably underrated, as it is the brightest in its neighbourhood. From this draw a 3rd line westward again, nearly perpendicular and equal to the 2nd, and therefore not far from parallel to the direction of the first, and it will fall upon 53 *Eridani*, 4 mag., which is also the brightest for some distance around. About $\frac{1}{3}$ of the distance from μ *Leporis* to 53 *Eridani*, but a little above the line joining them, we shall find our object; the region is rich in stars of various sizes, but if our aperture is sufficient (which is essential, as the star, a variable one, is now only 9 mag.), and our patience adequate, we shall come across it; and to those interested in star-colours, it will certainly repay the trouble. It is the last of a nearly horizontal line of 3, of which the first is by far the brightest, and was at once conspicuous with a power of 30 on my aperture, a magnificent crimson, finer than any I have yet seen.

We shall soon be losing the *Orion* Nebula. Mr. Huggins's wonderful discovery of the gaseous nature of this and many other nebulæ has given a fresh impulse to the study of these mysterious objects. We may well call them so; for even the resolved cluster, such as 13 or 15 or 92 M,* though it may be composed of suns resembling our own in their independent light and heat, yet must exist under conditions, and give rise to scenes, altogether foreign to the experience of attendants, like ourselves, upon a solitary star. We can hardly imagine skies flaming with countless suns of all apparent magnitudes surrounding us on every side—uninterrupted regions of perpetual day: nor can we comprehend the dynamical arrangements by which the stability of such mutually attracting multitudes can possibly be secured. But it is scarcely less wonderful to contemplate the existence of masses of luminous vapour, such as we are now called upon to conceive. We are taught to look upon them as standing out, with all their filmy tenuity, in an insulated form; glowing even to incandescence with an amount of heat that we can refer to nothing but the immediate Will of the First Great Cause, amid the intensity of cold supposed to pervade all open space; bounded occasionally notwithstanding their expansive character by tolerably definite outlines; cut into and pierced through by deep holes or clefts; gathered up here into the semblance of densely packed masses; there pulled out into long "wisps"

* Schultz at Upsala, with a 9½-inch object glass, finds that this brilliant object (No. 21 of our list) shows 2 half-resolved centres, extended nearly in the parallel, which can be sharply observed and measured: angle 46°·3 diff. of Dec. 9″ 1: of R. A. 0ˢ 9.

and streams, and thinned away into invisibility, to reappear, perhaps, after an interval, in freshened luminosity round some distant group of stars;—objects such as these cannot be regarded without astonishment. And among such objects an amount of structural change, perceptible at our distance, though barely intelligible upon any known ground, is evidently more conceivable than in densely crowded clusters, and we are therefore prepared to admit the indications of such movements with an amount of scrutiny in proportion less severe. Perhaps, for in such matters we may well adopt the language of increasing caution—*perhaps* the Great Nebula in *Orion* may be the nearest to ourselves of these masses, and there if anywhere we may expect to detect the results of change. And certainly such would be the first impression—and a very strong impression—from a collection of the designs of different observers. But a closer examination leads to the conviction that we are in a dilemma—either such changes must be more rapid than is in the least degree probable, or the margin, that must inevitably be left for differences of eyes, and instruments, and climates, and habits of observation and delineation and transferring to wood or stone or copper, will be found so inconveniently broad that we shall scarcely be able to draw any satisfactory inference even from what appear, and unquestionably were intended to be, most careful representations. These discrepancies we shall perhaps find a better opportunity of introducing to our readers in detail upon some future occasion, and when a greater amount of evidence has been brought to bear upon a question so interesting and yet so obscure. At present I would only remark that I have during this season noticed an irregular dark rift running from W. to E. between the trapezium and the stars 87 and 70 (see Diagram, Int. Obs. v. 59), but much nearer to the stars, seeming like a continuation of the N. edge of the *Sinus Magnus*, the great black opening *f* the trapezium, and leading into, and possibly through, a roundish dark opening or "lake," by no means a very difficult object, but the traces of which, as well as of the rift, are very equivocal in any designs which I have had an opportunity of examining. It may also be mentioned that I now see under all favourable circumstances, though of course as a most delicate object, the *Pons Schröteri*, or "bridging over" of the *Sinus Magnus*, notwithstanding that according to O. Struve's opinion (Int. Obs. iv. 261), it would hardly have been a suitable object for my aperture; and that Professor D'Arrest's remark in the spring of 1862, that it had been occasionally well seen in the Copenhagen achromatic of 11·2 inches aperture, implies but feeble intensity. I can now likewise perceive distinct traces of what I *think* I

formerly looked for in vain, the *Nebula Oblongata*, a very faint cloud lying off the opening of the *Sinus Magnus*, but nearest to its S. edge: the very region, it may be remarked, in which H. entertained the greatest suspicion of alteration (INT. OBS. iv. 260). Such minute varieties may have been nothing more than the working of a more experienced eye, and at any rate can only be placed among things which had better not be forgotten; it is more to the purpose that during a visit to Rome in Feb. 1865, O. Struve was enabled to confirm, with the achromatic there, the changes which he had previously suspected with his own.

Other indications of activity in nebular research may find a place here.

In 1837, Dr. Lamont, Conservator of the Munich Observatory, in an interesting essay on Nebulæ, containing, however, several questionable assertions, suggested that nebulous matter, properly so called, would be distinguished from very remote and irresolvable clusters, if actual translation in space were ever to be detected in it, as this would indicate a comparative nearness to our system, such faint rarified masses being presumably invisible at extreme distances. And he thought he actually did perceive, in several instances, a displacement far exceeding any change of position which could with probability be ascribed to a system of stars,—and the instances were exactly those ill-defined masses, whose aspect bespeaks their misty character, being resolvable neither into stellar points nor distinct portions. The latter kind of resolution Lamont considered inconsistent with the equilibrium of nebulæ proper, and therefore indicative of a starry character. But that he was mistaken in this, the Great Nebula in *Orion* alone is now sufficient to prove.

The "proper motion" thus ascribed to certain nebulæ, D'Arrest, one of the highest authorities, considers improbable; and it is sufficiently apparent that as H.'s observations were comprised between 1825 and 1833, any real change perceptible in 1837 would now have attained an amount admitting of no question. Yet the subject ought not to be summarily dismissed; for as we have already seen (INT. OBS. vi. 447, 449) H. and Lord Rosse are disposed to entertain it; and as Lamont's essay is not readily procurable, the following details are extracted from it, for the sake of those possessed of adequate optical means; not so much with the idea that his results will be verified, as with the hope that more careful measurements may be executed for the benefit of future observers.

In his catalogue of 1833, H. had repeatedly drawn attention to minute stars in the immediate vicinity of planetary

nebulæ, not however under the impression that by their means motion might be detected in those objects, but supposing that they might possibly prove to be satellites revolving round them; and he regrets that his measures of these stars were "hurried, imperfect, and discordant;"—the wonderful extent and admirable execution of his undertaking would have rendered it most surprising if they could have been otherwise. Of these positions of attendant stars Lamont remarks that many agree with his own, but some differ, especially the following:—

H 536 (280 $\frac{H}{o}$ II. Gen. Cat. 1721)—R.A. 8h. 47m. 20s. N.P.D. 92° 32′ 2″, is no longer equidistant between H.'s two stars.

[H 854 (M. 65. Gen. Cat. 2373)—R.A. 11h. 11m. 37s. N.P.D. 76° 8′ 47″, one of his strongest instances of rotation, is an error due to a misprint of 45° for 75° in H.'s Cat. 1833.]

H 2037 (743 $\frac{H}{o}$ III. Gen. Cat. 4487)—R.A. 19h. 11m. 37s. N.P.D. 83° 42′ 46″, has a star near it differing from H.'s position by—15°. On this object H. remarks (Cape Obss.) in 1847, that though Lamont has mistaken his (H.'s) stars, yet "from all the circumstances of the case, there can be very little doubt of a relative motion of the objects *inter se*." Class III. of $\frac{H}{o}$ consisting of "very faint nebulæ," and this object having been seen by D'Arrest with 4½ inches of aperture in twilight, it must be variable, unless atmospherically obscured when observed by $\frac{H}{o}$.

H 2075 (16 $\frac{H}{o}$ IV. Gen. Cat. 4572)—R.A. 20h. 16m. 8s. N.P.D. 70° 20′ 19″, seems to change its position pretty rapidly with regard to the neighbouring stars. This, however is doubted by Auwers.

H. 2241 (18 $\frac{H}{o}$ IV. Gen. Cat. 4964)—R.A. 23h. 19m. 10s. N.P.D. 48° 13′ 57″, he thinks has moved about 6″.—This is a very curious nebula. H. had seen its bluish-white light, at one time perfectly equable, at another rather mottled; the disc very nearly circular, beautifully defined with 240, but "the edges the least in the world unshaped," not nebulous, but as if it had a double outline, or like a star a little out of focus. His measures of position of the "satellite star" were very discordant, which he ascribes to the subsequent discovery of that star being double, 12 and 13 mags. Lassell, with his superior optical means, found it *bi-annular*, a nucleus with 2 oval rings. But the most remarkable singularity was detected by Huggins; this being the only nebula, as far as is stated in his memoir, in whose spectrum he has perceived a *fourth* excessively faint line, possibly one of those due to hydrogen. With 600 upon his 8-inch object-glass, it appeared to him distinctly annular and greenish blue.

We may here remark that there is now no longer any

mystery as regards the peculiar greenish or bluish tint so long and so frequently remarked in the planetary nebulæ. It is simply consequent upon their gaseous constitution, the bright bands exhibited by their materials under intense heat having the refrangibility and the colour of those portions of the spectrum. It should, however, be observed that there is some difference among these objects in this respect; and that this is *primâ facie* evidence of difference of constitution. Three remarkable instances of this may be specified. One is 27 $\frac{H}{o}$ IV, R.A. 10h. 18m. 2s. N.P.D. 107° 55′ 50″, about 2° S. of μ *Hydræ*, and visible in England, but catalogued by H. at the Cape as No. 3248 (Gen. Cat. 2102). Its colour is described by him as "a good sky blue," but "not so full a blue" as another, H. 3365 (Gen. Cat. 2581), which is of "a beautiful rich blue, between Prussian blue and verditter green . . . a feeble lamp light gives it a deep indigo contrasted colour. Ditto if a red star, n p, about 10′ distant, be brought into the field with it." The 3rd, on the other hand, H. 3594 (Gen. Cat. 4066), "a most elegant and delicate planetary nebula," equal to a star 8·9 mag., and "perfectly sharp, not the slightest haziness," is specified as having "a clear round planetary white disc." It is much to be regretted that these last two are out of the reach of the English spectroscope, and could not even be touched at the Roman observatory, where, we were told, a twelvemonth ago, that O. Struve was astonished at the magnificence of the stellar spectra, though he had previously seen those at Greenwich with a much larger aperture. Merz has since been at work for the same observatory, upon a yet finer spectroscope, with 2 prisms of 60°, and a dispersion double that of the ordinary Frauenhofer glass, producing a total deviation of more than 120°.

Some further details as to nebular researches must be postponed.

OCCULTATIONS.

April 9th, 8 Aquarii, 6 mag., 15h. 22m. to 16h. 16m.—18th, 111 Tauri, 6 mag., 10h. 57m. to 11h. 40m.—29th, μ Libra, 6 mag., 15h. 47m. to 16h. 15m.

ON THE APPLICATION OF RECENT SCIENTIFIC DISCOVERIES TO THE USEFUL ARTS.

BY PROFESSOR M'GAULEY.

No subject can be more interesting than that of the aid which scientific research has afforded to human progress. The career of mighty conquerors has been marked by devastation and blood. Populous cities have been changed by them into heaps of ruins; rich and highly-cultivated regions into "howling wildernesses." How different have been the results of peaceful research, the only object of which has been the benefit of mankind. If the perusal of history, as the record of splendid victories and terrible defeats, of oppression and the struggles of the oppressed, is much more calculated to produce feelings of pain than of pleasure, the consideration of those wonderful improvements in our condition which have been effected by men who are often as deeply absorbed in their ennobling studies, and as unconscious of the turmoil of the world around them as was Archimedes of the storming of Syracuse, are suited to call forth feelings of unalloyed pleasure.

The triumphs of genius and industry over the difficulties with which the path of progress is beset, meet us wherever we turn. There are periods at which our advance has been exceptionally rapid; one of the most remarkable of these is comprehended within the present century, and chiefly within the more recent portions of it. The differences between the advantages which we enjoy, and for which we are indebted to science, and those possessed by our immediate predecessors, is scarcely less great than that between the condition of the polished Romans and the Britons whom they subdued.

An acquaintance with what has been already done, and with the difficulties which others have surmounted by ingenuity and peseverance, creates a powerful tendency to further exertion. The records of science abound with examples of sudden and rapid strides, on account of the attention of mankind being turned to some principle, or some fact, which perhaps had been long known, but as long neglected. The properties of steam have, no doubt, at all times, attracted notice: but they were never usefully applied, until the Marquis of Worcester, Savory, Newcomen, and Watt rendered them, by their researches, the subject of deep and general interest. Good service is therefore done, when the public mind is strongly directed to what science has already achieved. But much as the experimentalist has done, there is no reason to

suppose that a thousand times as much will not hereafter be accomplished. There is not one who, if he try, may not strike on some vein of useful discovery, that shall place his name in the list of the benefactors of his race.

It would, of course, be impossible, within the limits of one or two papers, however long they might be made, to touch on even a small portion of the applications of science to useful purposes. We shall, therefore, be obliged to content ourselves with the selection of a few examples from among those which appear best to illustrate the great advantages that have been conferred by the thinker and the experimentalist on arts and manufactures.

Among the contrivances which benefit mankind, none are of greater utility than those which effect a saving of labour. In former times, the production of works at all remarkable for their vastness, was the result of a painful struggle between brute force and the laws of nature. Refractory materials were rent asunder, and the fragments carried to where they were required, only by the most exhausting exertions. To build the great pyramid required the labour of 100,000 men for twenty years, and during the work a very large number of them perished miserably through excessive toil. And yet, how insignificant are all the pyramids, taken together, in comparison with the mighty works constructed with ease, and without the loss of a single life through over exertion, by the modern engineer, on even one railway; thanks to men of science who have furnished him with those appliances which have caused every difficulty to vanish. Mere physical labour has, in a great degree, been transferred to automatic machines, that require little more than a superintendence, which, being an operation of the mind, is calculated not to degrade but to elevate.

The use of atmospheric air for the transmission of force is among the simplest applications of science to industrial purposes. We shall glance at a few of the methods which have been employed for the purpose. The wind has indeed long been used as a source of motion; but its uncertainty and varying force have rendered the effect which may be obtained from it of but little value. The air is far more usefully applied to the storeing up, or the transmission of power, which may be used when and where it might not have been convenient or even possible to obtain it from other sources. Its efficiency may be derived from either increased or diminished pressure.

The possibility of impelling carriages on railways by means of atmosphere pressure, suggested itself long since; but the difficulties with which the carrying out of the project was beset,

and the wrong principles that were adopted in the attempt to do so, rendered, until recently, all experiments on the subject unsuccessful. The very earliest idea was that the carriages should travel within a tube; but it was abandoned, from a supposition that it would be impossible to remain with comfort, or even with safety, in such circumstances. A piston, moving inside the tube, and connected by means of a long valve with carriages external to it, was therefore adopted. But no amount of ingenuity or care was found sufficient to prevent a leakage that caused a loss of power incompatible with the profitable working of such a line. The leakage was the more serious from the considerable difference between the pressure required at each side of the piston. It has been found that when the carriages or waggons are within the tube, a pressure of three or four ounces per square inch will suffice for all desirable velocities—two and a half ounces are enough to produce a speed of thirty or forty miles an hour. But when there is a travelling piston, and a valve the whole length of the tube, to allow the bar connecting the piston and carriages to pass along it, from 120 to 160 ounces are indispensable.

The history of the atmospheric railway furnishes an example of the abandonment of a valuable principle, simply because unscientific means were used for carrying it out, and difficulties which had no existence were taken for granted. In the infancy of the locomotive, a similarly unfounded assumption of insufficient adhesion between the driving wheels and the rails led to a great waste of ingenuity, and to a large and useless expenditure of time and money.

The application of atmospheric pressure to the propulsion of vehicles might have long remained in abeyance, had not the Pneumatic Despatch Company applied the principle to the conveyance of letters and merchandize, and thus afforded an opportunity of proving that even human beings might continue without inconvenience in a closed tube. The removal of an apparently insuperable objection to atmospheric propulsion which has thus taken place is of the highest importance; since, with a pneumatic railway, the danger of accident is diminished almost to nothing; collisions are made absolutely impossible; and since a train cannot, in any circumstances, run off the line, the greatest velocity is unaccompanied by danger. The view of external objects is, indeed, altogether excluded; but this privation is little greater than that experienced on ordinary railways from the number of cuttings, tunnels, and interposed objects, and the high speed.

With an atmospheric railway, the expense of construction and maintenance are greatly diminished; steep gradients and sharp curves cease to be objectionable, since an ascent of one

in fifteen, or a curve of eight chains radius, causes no inconvenience, and great facilities are afforded by it for passing under rivers.

The elasticity of the air has been applied in numberless other ways. Reducing its pressure during evaporation had led to extraordinary economy in the manufacture of cane sugar; and to the removal of all disagreeable smell and danger of explosion from petroleum. Bridge building has been greatly facilitated by exhausting the air within the caissons sunk for the foundation of piers, which causes the silt and mud to rise up within them, so as to be easily removed; or by keeping the water out of the caisson, while the excavation is being carried on, the air within it being compressed. The process used in the manufacture of soda has been simplified by discovery of the fact that sulphate of baryta is decomposed by caustic lime, at a pressure greater than that of the atmosphere.

Compressed air is applied very effectively to the transmission of power. Thus, in giving motion to the shuttle in weaving, and on the large scale in the tunnel which is being cut under the Alps near Mont Cenis. The air, in the latter case, is condensed by water power outside, and is conveyed by pipes into the excavation, where it gives motion to the chisels that perforate the rock, forming cavities for the gunpowder used in blasting.

The contrivances employed as convenient substitutes for human labour are not set in motion by air only; water pressure also is employed with great advantage for the purpose. The water-wheel, like the windmill, is of ancient date, and, like it, is unsuited in ordinary cases to the production of motion. The pressure of water has therefore been otherwise and more effectively applied — very often by means of an engine bearing a very close resemblance to the steam engine, and differing from it only in consequence of the difference between the properties of non-elastic and elastic fluids: a difference which was long a source of great difficulties. A water pressure of between sixty and seventy pounds to the square inch is found sufficient for all ordinary purposes, and may be obtained from the water supply of most great towns and cities. Water, on account of its freedom from danger, and the facility with which its pressure is transmitted from one place to another by means of pipes, as well as its economy and easy application, will most probably before long come into very general use.

The discovery of means for propelling machinery by air or water pressure has been the cause of great improvements in mining. The idea of substituting mechanical for hand labour

in mining operations is not, indeed, new. Hunter, who invented machinery for cutting and planing stone, turned his attention also to machines for boring and drilling; and many ingenious men, both in this and other countries, afterwards took up the subject, with various degrees of success.

The earlier attempts at mining and tunneling by machinery appear to have been founded on wrong principles. Thus, in Peurice's machine, which excited great attention some years ago, a plate equal in size to the tunnel, and having several hundred chisels fixed on its face, was moved backwards and forwards by a piston with which it was connected. But the sudden jerks of so heavy a mass were destructive to the chisels, especially when they came in contact with hard portions of the rock—and as no provision was made for replacing them. With Gray's engine there was a similar disc, but it revolved; the chisels therefore moved with a velocity dependent on their distance from the centre; and, consequently, the work done by some of them must have been very severe. Such an apparatus involved serious defects; it exerted only a scraping action, which rapidly wore out the chisels, and was not nearly so effective in perforating rock as rapidly succeeding blows. In the machines used in the tunnel of Mont Cenis these imperfections have been avoided. Small perforators travel on a carriage, each of them being a kind of horizontal air-pressure engine, the prolonged piston-rod of which carries a jumper that makes 250 strokes a minute. The excess of pressure on each jumper, above that of the air-spring which brings it back, is 216 pounds; and hence a very considerable power is brought into action. Various kinds of mining machines are now employed, some of them forming either horizontal or vertical grooves.

Machinery has never been more usefully applied than in cutting coal. If this is done by hand, the labour is not only degrading and severe, but highly dangerous; since, when the coal is undermined, it but too often tumbles down on the miner, crushing and burying him alive. There is great economy in coal mining by machinery. In under-cutting by hand, the opening must be very wide in front, or it will be impossible to get at its inner portions, as it must be about three feet deep. The coal thus removed by the miners is so small, as to be nearly valueless. When the cut is made by a machine, it is extremely narrow, and thus a great saving is effected. As soon as the groove is sufficiently deep, the coal falls by its own weight, or is forced down by wedges; but should it fall by itself, it can do no injury.

The process of puddling by hand ranks next to coal-cutting in severity; but as it requires great strength and

considerable skill, it is well paid for; and the number suited for the operation being limited, puddlers can enforce the acceptance of almost their own terms, to, in many cases, the great detriment of the iron manufacture. Puddling, which changes crude into malleable iron, is intended to expose every portion of the metal thoroughly to the air, at a very high temperature, that the excess of carbon, which causes it to differ from malleable iron, may be burned off.

The idea of superseding the objectionable and exhausting process of puddling by hand is not new; but only recently, and to a partial extent, have the attempts which have been made for the purpose been crowned with success. It is difficult to devise automatic machinery for puddling; the movements are peculiar, and it is necessary to renew the instrument very frequently, on account of the high temperature. The aid of the workmen can never be entirely dispensed with, since intelligence is necessary for determining the moment at which the mass becomes in a spongy condition, and therefore requires a change of treatment. The last-mentioned circumstance renders it possible to supersede only the severest portions of the labour; and hence, when the metal begins to agglomerate, the work of the machine ceases, and that of the puddler begins. But the application of machinery, even to this extent, greatly diminishes the amount of manual labour, shortens the time required, lessens the consumption of fuel, and even improves the product.

The importance of any successful modification of the puddling process may be inferred from the vast quantity of wrought iron required at present: but it has been found very difficult to introduce any machinery connected with it. Iron masters could not be persuaded that an operation in which so much depends on watchfulness and skill, could be even partially carried out by mechanical appliances. Not only must carbon, silex, and perhaps phosphorus, be got rid of, but a part of the silicate of iron, or fusible slag, must, for some reason, which as yet is unknown, be kneaded up with the iron. The slag, it is probable, elongates the crystals under the roller, so as to change them into fibres—a transformation which is indispensable to strength. When the oxidising flame of the furnace is to be converted into a neutral, by shutting the door of the damper, the kneading of the silicate must have been completed; since, if the metal is not withdrawn at the proper time, an injurious chemical change would begin: much, therefore, still depends on the puddler. If intelligence were not required during a portion of the process, there might be hope that some time or another the whole of it would be carried on by machinery. The introduction of the latter, however, even

to a limited extent, has been attended with great advantages, and especially when grey iron, which remains longer in the fluid state, is manipulated; the labour with this being greater, and, therefore, when performed by hand, more exhausting.

It is found that, with the machine, five hundred weight may be puddled in the time which would be required for puddling four by hand, and the work is better done. The superiority of the product is partly accounted for by the fact, that the workman, however great his assiduity and skill, leaves a portion of the iron in the crude state. When the puddling-machine is used, the required transformations are effected more completely, and with greater uniformity. The heavier part of the work being already executed, the workmen come fresh to their portions of it: and their strength, instead of having been wasted on that which requires mere physical force, is reserved for the more important and delicate details of the operation.

The process invented by Bessemer is intimately connected with that which we have just noticed: it is, indeed, fundamentally the same, the very same object—the combustion of the carbon—being sought to be attained in both, though by different means. No improvement in manufacture has been attended with more important results, and none more thoroughly illustrates the advantages conferred by science on the useful arts. It was suggested by science, it was brought to perfection by science, and there is nothing connected with it that is not founded on scientific principles. It has conferred incalculable benefits, either directly or indirectly, on every branch of manufacture.

To obtain malleable iron from the ore, the oxygen, etc., found in combination with it, must be removed. This is effected by bringing it in contact with carbon at a high temperature, the ore having been previously roasted to expel moisture. Unfortunately for the simplicity of the operation, the iron, when it is deprived of the oxygen, combines with carbon, crude iron, which is fusible, but neither malleable nor ductile, being formed. The carbon is, in its turn, banished, ordinarily by the operation of puddling. But, by the Bessemer process, instead of the fused iron being stirred in contact with atmospheric air, the latter is blown through it, and is thus made to act, not only on the surface, but throughout the entire mass, and to exert not only a chemical effect, but—which is of the greatest importance—a mechanical also; the molten mass being dashed into spray, and therefore thoroughly exposed to the oxidising agents. The action produced in this way is so energetic that a very intense heat results; and the

iron, even when reduced to the malleable state, and therefore extremely infusible, is kept so fluid that it may be poured into moulds.

The chief difficulty attending this process appears to be the stopping it at the right time; for it is evident that, if continued after all the carbon has been consumed, the iron itself will be oxidized; in which case, not only will there be waste, but the quality of the result will be deteriorated. The manganese, however, which is now always added, either combines with the excess of oxygen, towards the end of the process, or —which is more probable—renders the iron more fluid, and thus allows the oxide of iron, along with other impurities, to rise more easily to the surface.

It is clear that steel may be obtained from crude iron, by removing just enough of the carbon to leave the amount which is required to constitute steel; and this is one of the methods employed. But it is very obvious that the goodness of the steel thus obtained must altogether depend on the operation being stopped at the proper moment; which, if not impossible, is extremely difficult, whatever care may be taken, or however the quantity of atmospheric air employed may be proportioned to the amount of crude iron which is to be changed. The method which affords, with more certainty, a good result, consists in burning away the whole of the carbon: and then adding so much crude iron, or of some mixture containing the required quantities of carbon, silex, and manganese, that there shall be, in the whole mass, just enough of each constituent to form steel.

The Bessemer process is one of the most recent of our manufacturing improvements, and yet it is rapidly approaching to almost general adoption. It was first made known to the public in 1856, and, although but ten years have elapsed since that time, 100,000 tons of steel are now by means of it made annually. It must not be supposed that it is founded on any new principle—it is merely another instance of the happy and ingenious application of something long before known, though little or not at all utilized. Air has been blown through fused cast iron for at least three hundred years, and iron has been prepared for puddling in this way for one hundred years. But, obvious as the adaptation of such a process to the making of steel or of malleable iron might appear to be, it was never used for these purposes until Bessemer, fortunately for himself, and still more fortunately for the arts and manufactures, hit on the happy idea of thus employing it. The great secret of his success consists in the *mechanical* use he makes of the blast; without this the decomposition would be irregular or incomplete. And it is this

apparently trifling circumstance which gave a novelty and a real value to the manipulation he adopted.

The immense value of the Bessemer process arises from the extraordinary economy with which a most valuable article may be produced. It has already furnished steel at £12 per ton; and it is capable of supplying it as cheaply as wrought iron. The difference between the strength and durability of iron and steel is very great. It has been found that without being worn out themselves, steel rails on railways will wear out seventeen faces of iron rails exposed to but the very same treatment. The Bessemer process is capable of producing the steel required for the most delicate purposes; Swedish tool steel, formed by means of it, and remelted to secure perfect uniformity, is so excellent as to sell at £65 per ton.

The last application of science to which I shall, on this occasion, direct attention, is that of electro-metallurgy. It admirably illustrates the important results which may follow from the observation of a simple, and seemingly, an unimportant circumstance, by an intelligent man of science. Who could have imagined that the convulsions which Volta remarked in the limbs of a frog, during an anatomical experiment, would have led to the discovery of that vast amount of knowledge which now constitutes electrical science, with its multitudinous applications to the arts. To electricity we owe telegraphy, which, in the most literal sense, annihilates both time and space; and electro-metallurgy, which gives us almost unbounded dominion over the metals, enables us to produce with ease, and at a trifling cost, the most complicated and costly works of art, and lends its aid to nearly every branch of manufacture.

Formerly, almost all metallurgical operations were carried on by means of fire; but galvanism has, to a great extent, superseded the use of the furnace. Electro-metallurgy was not the result of a fortunate inspiration, or the simple development of some well-known principle which had been long neglected; it is the result of a long series of ingenious and successful experiments and investigations. So long ago as the commencement of the present century, it was noticed that the elements of a compound went to opposite poles of the galvanic battery; and that, when silver, in contact with a more positive metal, is put into a solution of copper, the silver is coated with copper in a state which allows it to be burnished—a fact that constitutes the very foundation of the electrotype process; and in 1805, Brugnatelli gilded by means of an ammoniuret of gold. But in consequence of a strange apathy, which is sometimes observed during the development of the most important discoveries, little or no further progress was made for more than thirty years, when De la Rue remarked the

important fact that the copper deposited on the copper plate of the galvanic battery, on being stripped off, affords an exact *fac simile* of that plate in opposite relief. This was a discovery of too great value to be neglected: other experimentalists prosecuted the inquiry it suggested; and what originally was the source of mere philosophical recreation, was soon developed into a valuable art, and ultimately into an important branch of trade.

Great difficulties were at first experienced in manipulating with the noble metals: but they were at an end when, in 1840, it was discovered that their oxides or cyanides are soluble in the alkaline cyanides. It was then possible to obtain them in firm, adherent, and bright films: and when it was ascertained, a few years after, that silver is deposited in a bright state if sulphuret of carbon is present, the art of electroplating attained its highest perfection.

The application of electro-metallurgy to other branches of manufacture are, perhaps, still more important. It affords a cheap and convenient mode of multiplying the most costly engravings. An engraved copperplate cannot, without being worn out, afford more than a very small number of proofs, which perceptibly deteriorate as the number progresses. To meet the cost of production, it was necessary to charge a high price for each proof, and as those who were able to pay thus liberally were very few, there was little encouragement even for the most distinguished artists. But when the electrotype process supplied a mode of multiplying to any extent copies, all of which were almost equally perfect, an immense sale, which was the natural consequence, abundantly remunerated both the artist and the publisher, though the price charged was greatly lower; and led to the production of many a noble work, which in other circumstances would never have existed.

In addition to this, the electrotype process has made the choice productions of one country available to every other; since any number of *fac similes* of an engraving on copper or wood may be obtained by it for little more than the the price of the metal. In this way we secure, at a moderate cost, the best productions of France and Germany; which, in return, receive from us copies of the most successful works of our own artists.

Electro-metallurgy may now be considered to have all but reached perfection. The various useful metals, almost without exception, can be deposited either singly or in combination on each other from alkaline solutions; the precipitation of their oxides being prevented by the presence of organic matter. The cheap and simple means thus presented of coating the

inferior with the more valuable and less perishable metals, must be attended with the greatest advantages in manufacturing and domestic operations.

In returning to this interesting subject, we shall consider some applications of scientific discovery of a different kind, but of a not less important character.

ON THE DEVELOPMENT OF THE OVUM OF THE COMMON NEWT, TRITON CRISTATUS.

BY THE REV. F. HOWLETT, M.A., F.R.A.S.

(*With a Coloured Plate.*)

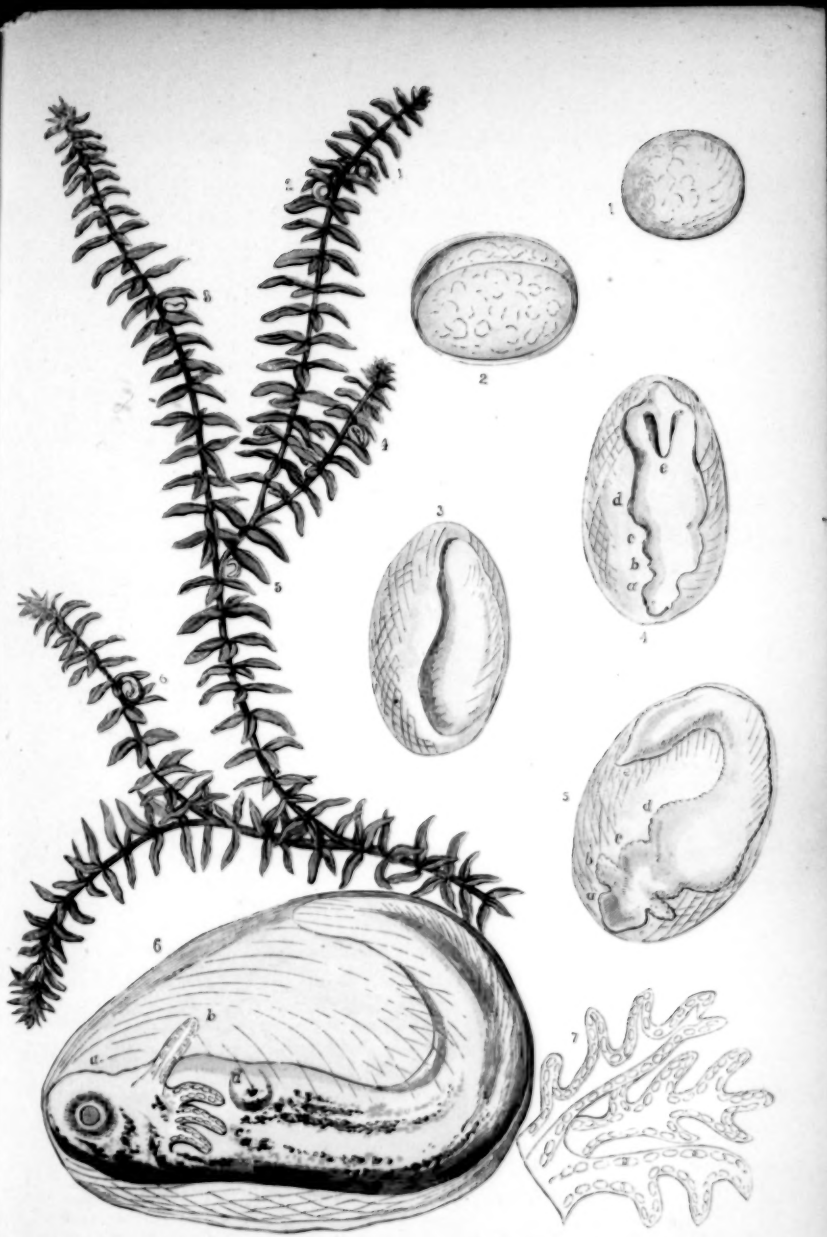
As the spring approaches, we would recommend all those who conveniently can, and who may not as yet have investigated the subject, to prepare for the examination of certain vital phenomena, which cannot fail to afford deep interest to the student of natural history, be his attainments in that fascinating science greater or less.

We allude now more especially to the beautiful and very easily observed process of the development from the ovum or egg of one of the commonest tenants of our ponds and ditches, the eft or water-newt, of which two species are found in this country, viz., *Triton cristatus* (the common water-newt, and subject of this paper), and *T. palustris*, or the large warty-newt.

To see this phenomenon to the best advantage, the method about to be described will be found very effectual and satisfactory.

In the first place, ascertain by at latest the middle of April that your aquarium or other convenient receptacle for water is in good order, and furnished with some aquatic plants of clean and healthy growth, and (for the purpose in hand) of small and neat foliage, such as *Anacharis alsinastrum* (one of the best and most readily procurable), *Callitriche*, *Myriophylum*, or the characeous plant, *Nitella translucens*, the transparent nitella, which last, for other special reasons to be mentioned presently, is a great favourite with the writer, and is found very commonly in the ponds in his locality, in the Weald of Sussex.

Your aquarium, then, having been thus furnished, look out during warm sunny days from about the middle of April to the middle of May, for any female newts, which then (pursued frequently by some male admirer) may be observed swimming



EGG OF NEWT (Triton cristatus) AND ITS DEVELOPMENT.

Fig. 1, May 25. Fig. 2, May 29. Fig. 3, June 2. Fig. 4, June 4. Fig. 5, June 6. Fig. 6, June 8. Figs. 1 to 5 mag. 8 diameters. Fig. 6 mag. 15.

in the ponds, near the surface of the water. They may be readily distinguished by the comparative absence of that wavy, handsome, dorsal fin-like membrane which is so conspicuous on the back of the males.

Select those females which by their somewhat superior bulk may be known to be already in a condition to commence laying their eggs; and having placed two or three of them in your aquarium, you will find that they will very soon begin to deposit their eggs, one by one, amongst the foliage of your *Anacharis*, or other plant, slightly concealing them, probably, by drawing two or three of the leaves together by means of their hind legs. At the same time have in readiness one or two of the neat glass troughs, sold by any microscope-maker, about three inches or so in length, and two inches broad; and properly furnished also with a loose plate of glass placed obliquely inside, in order to secure steadiness in the object to be magnified, and to regulate the depth of water through which it may be desirable to view it. Then detach half-a-dozen or so of your ova from the leaves wherein they have been deposited, and place them carefully in your glass trough, taking a note of the day or days whereon they were laid by the parent newts; which, by the way, are sometimes nefariously disposed, when pressed by hunger, to devour their ova; and hence the more need to remove some betimes to a place of safe custody.

The process by which they may then be seen to develope, and presently to be hatched, will be readily observed; with a rapidity, moreover, proportionate to the elevation or depression of the temperature to which they shall have been subjected in the troughs.

The eggs when first laid are about the size of mustard seeds, and of a yellowish gray colour; and consist of a soft granular mass, invested in a closely-fitting transparent membrane, the zona pellucida or vitelline sac.

One point of great interest in connection with the development of the ova of the frog, toad, newt, and some other reptiles consists in the fact that the embryo animal gradually evolved from them, does not derive its origin from any one germinal vesicle upon the surface of the yelk (which *is* the case with not only all birds, but also, it would appear, with the microscopic ova of the mammalia themselves), but the whole mass of the yelk may be seen to be gradually *moulded*, as it were, into the young larva or tadpole, in the method illustrated by the accompanying plate, and all of which was witnessed and drawn by the writer of this article, in the spring of last year, 1865. It should be remembered, by the way, that the temperature last spring was unusually high for this

country, otherwise the development of the young newts would have been much more tardy, as any observer may prove by keeping one set of ova in a room with only a northern aspect, and another in one exposed to the sunny south, when it will be found that the latter will be hatched several days before the former.

The plant represented in the plate is a portion of *Anacharis alsinastrum*, and shows both the way in which the female newt deposits her eggs amongst the foliage, as well as the successive stages through which the substance of an egg passes on its way towards the development of the tadpole, which ultimately proceeds from it.

The subject from which the drawings were taken was, indeed, hatched in a glass trough, apart from the plant to which it had been attached, but from time to time the writer transferred other eggs, together with portions of the nitella or of the anacharis amidst which they had been laid, from his aquarium, when the same phenomenon as those about to be described were again and again verified.

No 1—in the first instance represented in its natural size among the foliage of anacharis, and also, secondly, as seen under a low magnifying power of about eight diameters—exhibits the ovum as it appeared on the day it was laid, May 25th, 1865, consisting, as we before said, of a soft, yellowish gray, slightly-granulated mass, closely surrounded by its transparent vitelline sac. On May 28th, this sac, perhaps by a combination of vital force accompanied by aquatic endosmose, had become slightly distended, standing away in places from the yelk within, which last had now begun to exhibit a sort of segmentation or tendency to divide itself, strongly resembling, in fact, the cleft in the young peach or apricot; whilst other ova of slightly different ages, and seen too in varying positions, looked not a little like minute bales of wool, or other elastic material, compressed tightly with cords, showing, therefore, a still further tendency to segmentation, preparatory to the protrusion of the various embryo limbs of the nascent tadpole.

This state of things began to be considerably more apparent in the same ovum on June 2nd (see fig. 3), and still more so on the 4th of that month, as shown in fig. 4; where, at the upper extremity of the ovum, the caudal part of the vertebral column may be seen first projecting outwards from the general mass, and then curving downwards, and terminating in a short, blunt, rudimentary tail, *e*. The hyaloid membrane had now also become much more distended, but still preserving its oval form, which, indeed, it retained to the last.

At this stage, also, appeared indications, at the point *a*, of the head of the little creature, together with the eyes; as well

also, at *b*, of what afterwards may be seen to prove one of the single cylindrical branchial tubes with which the tadpole becomes furnished; whilst *c* shows traces of what becomes a more complicated and eventually palmated set of branchial tubes, serving the purpose of gills; *d* being a protuberance which furnishes one of the anterior legs, the hinder ones (as is the case also with the frog and toad), not being developed till some little time after the tadpole has emerged from the ovum.

In fig. 5, for June 6th, all the above-mentioned features may be seen somewhat further developed, the little creature, moreover, having somewhat changed its position, whilst at the same time its skin had become much more highly organized, and presented that tuberculated or warty, and also transparent structure, which is so apparent in the cast-off cuticle which the newt, even when full grown, may often be seen to leave behind him (or her, as the case may be) in the water after changing its coat.

Fig. 6 shows our newt when much more fully developed on June 8th. The head and eye were now plainly apparent, though the integuments of the eye (the cornea more especially) were far from having attained that perfect transparency necessary for distinct vision. The cylindrical tube, *b*, was well exhibited, as also the commencement of the palmated set of tubes, *c*; and a somewhat more advanced, though as yet only still a faint notion, of the anterior leg at *d*. On this day, too, the highly interesting phenomenon of the circulation of the blood in the branchial tubes first became apparent; and which, when the tadpole has fairly emerged from the ovum, and begun (where food is plentiful) to grow rapidly, affords that magnificent spectacle so well known to microscopists; and which is but very unworthily hinted at in Fig. 7: which is merely a partially-worked sketch of a portion of one of the more matured palmated tubes of a newt magnified about sixty diameters. At this stage (when the newt, that is, has fairly left the egg, and which event, in the case of the little creature which has been now under our notice, happened on June 11th) the blood corpuscles may be seen to have attained their full size, clear sharp outline, and that *oval* shape which is characteristic of all vertebrated *oviparous* animals, whether bird, fish, newt, snake, or any other form also of reptile: whilst previously to the newt's having left the membrane in which it was developed, and consequently before its organs of respiration could have had free contact with the oxygen of either water or atmospheric air, the blood corpuscles possessed no regular outline at all, but they consisted of a multitude of small, variously-shaped granulated masses; those moreover in the single cylindrical tubes being smaller and less abundant than those in the more pal-

mated ones; and, indeed elaborating, seemingly, a sanguinous fluid of a somewhat different character than that which circulated through the tubes last-mentioned, and destined, perhaps, for the nourishment of some special tissues, or organs.

This point would form, probably, a very interesting subject for investigation to the more practised comparative anatomist.

The writer, moreover, must not omit to notice in passing, that on June 8th aforesaid, he observed a circulation plainly going on amongst the transparent lymph, with which the whole of the vitelline membrane was filled. The fact was indicated by the movement of a few sparsely-scattered granules contained within the sac, and which would seem to have derived their activity from the impulse imparted, perhaps, to the whole of the lymphatic fluid by means of the circulation and slight pulsations of the branchial tubes.

The vitelline sac, too, is not devoid of interest; possessing, as it does, in consequence of its corrugated and mesh-like structure, a singular facility for expanding to any limits requisite for the welfare of the little animal enclosed within.

Again, whilst the circulation of the blood in the external branchial tubes of the newt may at all times be clearly observed in any sufficiently-developed specimen, whether hatched or not—the pulsations of the heart itself, and the actual propulsion from, and again the reception by that organ of the vital fluid is not so readily seen; owing, of course, to the lack of transparency in the integuments of the creature's body.

Under certain conditions, however, this transparency is found to be very considerably increased, as shall presently be described. But, previously, let the writer assure every genial and gentle reader who may cast an eye over these pages that it was by no means by *malice prepense*, but by pure accident, that by dint of starvation he gained a little more knowledge about the state of the heart of some of his little captive newts.

The fact is, that two or three young individuals had once unwittingly been left behind in a small jar containing some of the writer's favourite nitella, whilst their more fortunate companions had been transferred to a tank where their wants were sufficiently attended to. But a bright beam of sunshine penetrating one day, about a month afterwards, into the small jar aforesaid, revealed the existence of certain awkward-looking, small, yet proportionately big-headed and emaciated young newts whom he recognized as some of his little bantlings, and presently conveyed tenderly to a small glass trough; where, not only was there plenty of infusorial and minute crustacean prey, but where, after the pangs of hunger had been appeased, he was enabled to perceive, through their

lately long fasting, and consequently, as it proved, highly transparent bodies, their little hearts beating merrily under the combined influences of a return to contentment and good cheer.

When lying in a somewhat more favourable position than usual in the glass trough, both the contraction, and in turn the dilatation (the systolic and diastolic action), of the heart was plainly and beautifully apparent.

As taught by some of the older, but yet eminent anatomists, as Boerhave, Haller, etc., the heart of the newt, like that of the generality of amphibials, seemed decidedly to the writer of this article to be unilocular, or furnished only with a single ventricle and a single auricle. Their blood is cold, though red; and they possess the faculty of suspending respiration at pleasure to a considerable extent; and along with that, a happy capability (as we have just seen) of enduring a degree of abstinence which would certainly prove fatal among the higher classes of animal life.

Speaking, however, of the structure of the heart in amphibial reptiles, such as the Triton, Siren, Testudo (turtle and tortoise), etc., considerable variety and modification is held to exist. The most perfect, perhaps, of the amphibials is the tortoise; yet Linnæus, and many of the older French writers also, assert that the tortoise has three ventricles instead of one, whilst later anatomists say that the heart of most of the amphibia is furnished with two ventricles; possessing, however, free intercommunication one with the other.

The siren, be it observed, is furnished at all times with both lungs and gills; and hence it may well be supposed that its circulatory system is somewhat complex. The newt, frog, and toad, moreover, whilst in their tadpole state, possess in their branchial tubes organs analogous to external lungs; but as these tubes cease to grow, and in process of time are absorbed and disappear as the animals arrive at a more matured stage of existence; so it must be presumed that their circulatory organs generally undergo considerable modifications suitable to the varying conditions of their amphibious state.

If, lastly, some of the *Nitella translucens* above alluded to be substituted instead of any of the more opaque-leaved aquatic plants, and the newt be allowed to deposit her ova amongst its delicate and transparent fronds, the student may soon enjoy the satisfaction of beholding, without any further preparation, the most striking and beautiful instances of both animal and vegetable circulation that can well be met with, going on at one and the same time.

But in connection with the circulation of nitella, including also the highly remarkable phenomena of spontaneous movements

exhibited in the process of its fertilization and fructification, so many beautiful and singular facts stand forth that it may well be worth while to make them the subject of a separate paper.

But, meanwhile, the wonderful adaptation of means towards their ends, and the free and varying employment of the elements of nature, as exhibited in the development of the pretty and perfectly harmless little amphibian which has now been treated of, afford an admirable instance of the wisdom and power of that Almighty Being, who, from the highest to the lowest realms of creation, shows that his care and "mercy are over all his works."

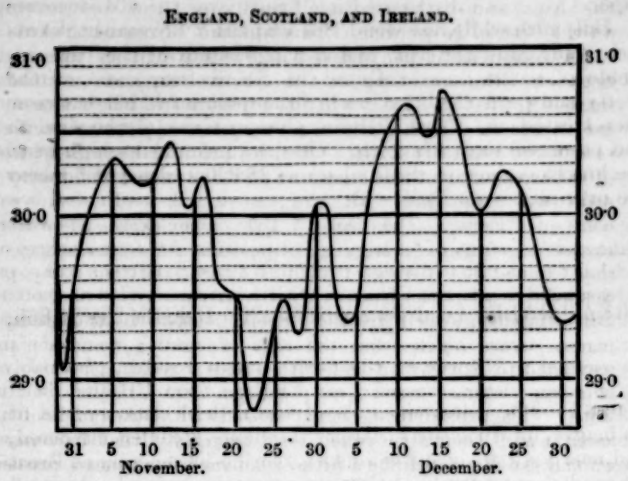
GREAT GALES OF NOVEMBER AND DECEMBER, 1865.

BY A. S. HERSCHEL, B.A.

When the late disastrous gale of the 11th of January was at its height, in which the ill-fated "London" steamer foundered, and nearly all on board were lost, marine barometers at Brest descended considerably below twenty-eight inches! A wheel barometer at Jersey went down so low as to reverse itself, and the index began to read a few degrees upon the opposite side of its scale. This was, however, a very exceptional case. The use of standard barometers makes it possible to trace with certainty the occurrence of much more frequent commotions of the atmosphere, that require the whole extent of Europe for their arena, and how much more of the surface of the Atlantic Ocean, for their production, is not at present known.

To trace their course upon a map, the pressure of the atmosphere must be laid down, together with the force and direction of the wind, at the same moment, at a number of widely-scattered places. When this is done, the pressure of the atmosphere, unlike the force and direction of the wind, appears to be so regular, and so free from sudden jumps and starts, that level lines for every fifth of an inch of variation can be drawn over many hundreds of thousands of square miles of sea and land, as certainly as if observatories existed at every point to verify their course, instead of only at about fifty or sixty places scattered over the map. The observations at seventeen places on the British coasts are thus daily printed in the Board of Trade Reports. The daily mean of these being taken, and shown in the following figure by a curve, exhibits the average height of the barometer over the whole

area of the British Isles, from the beginning of November to the end of December, 1865:—



Curve of the *Mean* Pressure of the Air in the British Isles, for the months of November and December, 1865.

From the 22nd of November to the 15th of December, the pressure increased from the remarkably low average of 28·829 inches to the unusually high average of 30·713 inches, being a difference of nearly a fifteenth part of its ordinary amount, *or one pound on every square inch* of the whole surface of these isles, by which the quantity of atmosphere in this country underwent an increase in the short space of about three weeks. Other places must, in the same time, have suffered a corresponding decrease, and this leads us to consider more generally the distribution of the aërial ocean upon the Continent, during the months of November and December.

Beginning with the south, the atmosperic pressure in the Mediterranean remained very nearly constant, about the mean, throughout both months. All the great oscillations of the barometer took place north of the water-shed of Europe, that begins at Cape Finistére, and running through the Pyrenees and Alps eastwards and northwards, comes to an end in the Carpathian mountains.

The month of November set in with high barometers in England, occasioned, apparently, by a depression in France, and by a still deeper depression in Russia, travelling from

Finland on the 9th, to the Black Sea on the 13th of November. An elevation, like the crest of a wave running S.W. and N.E., then traversed Europe south-eastwards, from Hamburgh to the Alps, and distributed itself finally over the Mediterranean on the 17th of November. This was the "November Wave."

As soon as it had passed a low state of the barometer began on the same date in the North Sea, and continued increasing till the 21st, when the pressure fell below twenty-nine inches in North Britain, a very notable depression, and so remained until the 24th. On the 22nd, the average height of the barometer in these isles was 28·829 inches; and a heavy south-west gale blew with fury on all the north and west coasts of Europe. The area of this remarkable depression showed no signs of changing its position for four successive days, but at last it divided itself into three portions: one part descended upon the Channel, with hurricane violence, on the 25th, inflicting, even upon the French coasts in the Mediterranean, severe gales from the east of south; another part ascended to Norway on the 26th; and a residue, probably of the same storm, crossed over England into Holland on the 28th. The disturbance then ceased with the end of the month, and December opened so tranquilly, that barometers on the 1st did not differ a fifth of an inch from mean pressure in any part of Europe! The great depression appears to have supplied itself by easterly gales from the high wave, called the "Great November Wave," whose crest had already passed over Europe, and had previously diffused itself over the Mediterranean; and in this manner the equilibrium was finally restored.

The calm was soon destined to be broken by a storm arriving from the Atlantic, which burst suddenly over the English Channel on the 4th of December; barometers at Brest fell rapidly as low as 28·66 inches, and the whole north and west coasts of Europe, as before, experienced a depression. The magazines of the winds appear, however, to have expended themselves in this effort, and the wind-bags in the Atlantic required replenishing, in order to renew their strength. Barometers began to rise, and at Riga they attained the enormous height of 30·92 inches on the 7th. Such an extraordinary elevation was only local, *but it spread;* and at the same time travelling southward to the Alps on the 9th, and westward to the English Channel on the 11th, the enormous inflation withdrew itself gradually across the western coast into the Atlantic. Pressure in this country, on the morning of the 15th of December, reached 30·713 inches; whilst at Riga the barometer already stood at 29·08 inches, being an extraordinary fall, at that place, of nearly two inches in eight

days. Immediately after the propagation of the high wave from Riga, two barometric depressions crossed the Gulf of Bothnia, the first to Moscow, the second to St. Petersburgh and Riga, where the latter in a few days disappeared. Barometers all over Europe continued high from the 17th until the 28th. Fresh storms then invaded the Continent from the direction of the Atlantic, and the year was brought to a close by weather so tempestuous, on the British coasts, that in the Channel, in Christmas week even the Dover and Calais packets refused to ply.

Some descriptions of the sudden and dangerous character of the winds in these storms, which follow, have been taken from the reports of captains in the daily papers. About 8000 foreign and coasting vessels come and go weekly in our ports, out of which it appears that, during the week ending November the 25th, 1865, the total number wrecked was 86, or fully one per cent. The number of wrecks in the same stormy week was little short of 100 per cent. above the average of previous weeks in 1865. Although one steamer from Weymouth ventured the passage, and reached Jersey in safety, no mails could be received from England, in the Channel Islands, from the 21st to the 25th of November.

A brig laden with sugar from the Mauritius, touching on her voyage at the Scilly Islands, to take up a pilot to guide the vessel into Bristol, remained at anchor in St. Mary's Roads from the 20th to the 22nd of November. "The weather in the mean time thickened, until about four o'clock on the morning of the 22nd, when the wind blew a complete hurricane from W.S.W. With both her anchors down, in the pitchy darkness the vessel drove nearer and nearer to the Mare Ledge Rocks on the south shore of Tresca Island. Knowing the dangerous position of the vessel, and that she would inevitably be thrown upon the rocks, the pilot advised that the masts should be cut away. This was done, and the vessel did not drive any more. At daylight it was found that the brig was only twice her own length from the rocks," from going upon which no human effort could have saved her, except only this last, and desperate resource.

The Wolf rock is a dangerous and solitary rock, rearing its crest above the sea, between the Scilly Islands and Land's End. On the morning of the 25th of November a large merchant-vessel, homeward bound from Calcutta, arrived within twenty miles of this much dreaded rock. The gale, which that morning blew in the Channel, continuing to increase till noon,—"the sails, close reefed, were blown away from their fastenings, and the sea made a clean breach over the vessel, when at two o'clock in the afternoon a beacon,

and breakers were suddenly seen to leeward. Sails were of no avail, as these were immediately blown to pieces, and nothing remained but, for the preservation of all, to cut away the mizenmast. The vessel canted, and providentially swung round the Wolf rock, then being about ten yards off."

Upon this exposed rock a lighthouse is now being built, as far as four courses of granite can raise it, which is only just above the natural hollow of the rock. Thirty-two stones of the fifth course were laid, secured in their places by cement as hard as iron, every stone joggled and dovetailed to its neighbours laterally and vertically, and bolted to the course below by powerful metal bars. This course, offering little opposition to the sea, was swept away; the metal bars remaining, some very much bent, others nearly upright; showing very clearly the nature of the watery upheaval by which the three-ton stones were torn from their bed.

At Penzance, on the same morning, the wind appeared to have subsided, but at noon the storm burst over Mount's Bay with a fury that in half an hour surpassed anything that had occurred in that locality for three quarters of a century. The spray of the sea was driven up the valleys a good half mile inland. The Newlyn Road is separated from the beach by a wall seven or eight feet in height, and over this wall hundreds and thousands of tons of shingle, composed of stones ranging up to thirty and forty pounds in weight, and even more, were hurled, and the road at some points was buried two feet deep under a stratum that rendered it, throughout its whole length, undistinguishable from the beach below. An inundation of the sea occurred at Helston, in Mount's Bay, and what was before a verdant valley became after the gale a sheet of turbid water. Window-panes in Penzance were blown in without injuring the frames. The streets were paved with slates; and the inhabitants were in a state of absolute terror. In the midst of the general alarm, the "Little Western" Scilly packet-steamer most unexpectedly appeared in view, and might almost be said to fly over the water towards the pier. When not a mile from safety two colossal waves rolling in, one after another threatened to overwhelm her. On the second she was borne safely into the harbour, almost grazing the pier, and escaping destruction by a hair's-breadth. The prospects at starting from the Scilly Islands were so fair, that the warning given by the barometer was disregarded, and its extraordinarily low state was attributed to a broken glass!

The gale of the 22nd of November, it has already been mentioned, was a "south-wester" upon all the western coasts of Europe. The wind began to rise, in London, about 9 A.M., and reached its greatest force (27 lbs. on the square foot) in

the forenoon, between ten and eleven o'clock. At Redruth, near the Land's End, the storm blew on Tuesday night, and Wednesday morning, the 22nd, passing away about 11 A.M. It commenced at Cardiff about 7 A.M., blowing with such force that the spray of the sea was thrown up thirty feet. At Bideford Bay, and at Portsmouth, the gale commenced at a very early hour, sheets of water breaking over the ramparts at Portsmouth throughout the morning. At places more towards the north the gale set in later in the day. It reached its maximum at Lynn, on the Wash, about three o'clock in the afternoon of the 22nd.

Again, in the Channel the morning of the following day was calm, but in the evening, at 10 P.M., the wind began to rise at Plymouth, and continued to increase till midnight, blowing a terrific gale on the morning of the 24th. The greatest force of this gale at Whitby, in Yorkshire, was not felt until 7·30 P.M. on the evening of that day.

Another lull in the Channel occurred at nightfall until morning; and towards noon of the 25th the third tempest of the series broke over the western ports, at first S.E., but at its height a complete hurricane from southward, with a sea and surf much heavier than in the two preceding gales. By sunset the wind moderated, making its way round to N.W. (as in the two previous storms), and going down to light airs from that quarter shortly after midnight. With the exception of further severe weather on the 26th and 28th, the Channel then remained for a while in a comparatively tranquil state.

On the night of the 3rd and morning of the 4th of December, a fresh storm approached the southern coasts. It was apparently cyclonic, arriving, like the rest, from the Atlantic, and emanating, it is reasonable to suppose, from the superheated region of the Gulf Stream, somewhere between Iceland and the Azores. A vessel crossing the Channel from Havre on the night of the 3rd of December, with the wind S.E. and the barometer at 28·50 inches, shipped a sea on her quarter, that broke the steering wheel to pieces and carried away the binnacle. On the morning of the 4th, with a heavy cross sea, and the barometer still at 28·50 inches, the wind shifted from S.E. to N.W. At noon the foremast broke, twelve feet from the deck, and by its weight in falling crushed the lifeboat. Although starting from the Havre with the wind in a fair quarter, owing to the sudden change in its direction the vessel took three days to make the Lizard, only arriving on the 5th.

Another vessel in the same storm met a greater mishap, apparently from a more trivial cause. Soon after midnight, on the morning of the 4th of December, with the wind from E. by S., a strong gale and a heavy sea, a schooner, coal-laden,

arrived from Neath in the neighbourhood of the Seven Stones, a dangerous ledge of rocks belonging to the Scilly group:—"Something being perceived in the water ahead, sail was made to keep clear of it; but the ship was unable to do so, and struck upon a wreck, or portions of a former wreck. In less than five minutes the vessel was filled with water. Pushing off in the boats, the crew had scarcely got twenty yards from the schooner when she foundered stern foremost, and disappeared in less than ten minutes from the time of striking."

Navigation in our intricate channels is rendered so perilous in heavy weather, that a wide berth requires to be given to the passage of these destructive gales, which a falling state of the barometer always certainly predicts.

A remarkable verification was given by the two gales at the latter end of November and beginning of December last, to the writing on barometers—

"Long foretold, long last;
Short notice, soon past."

STAR MAPS.*

Those who are acquainted with the principles of map making will understand the nature of the star maps which Mr. Proctor, the author of *Saturn and its System*, has recently produced, when we say that they are on the gnomonic projection, in twelve divisions, corresponding with the sides of a dodecahedron circumscribing a sphere. Such a technical statement will, however, convey no information to the majority of persons, as rudimentary scientific information on such subjects is rarely communicated in schools, and only a few take the pains to acquire it by private study after their tutors and masters have turned them out in sufficient ignorance upon the world. If we want a delineation of the earth, or any other globe, upon flat surfaces, it is evident that some principle of accommodation must be adopted, as a flat surface cannot be an exact representation of another surface, which is rounded so as to form a portion of a sphere. A transposition of the appearances on a rounded surface, to their *equivalent representatives* on a flat surface, must evidently be made in accordance with geometrical principles, or there could be no assurance of its accuracy. The simplest way of arriving at an idea of

* *The Stars, in Twelve Maps, on the Gnomonic Projection, collected in duplicate in Four Plates.* By Richard A. Proctor, B.A., author of "Saturn and its System," late Scholar of St. John's College, Cambridge, and King's College, London. Longmans.

the kind of accommodation that has to be made is to hold a sheet of glass horizontally over a globe representing the earth or the heavens, let the centre of the glass touch the globe, and then draw ink lines corresponding with the outlines of an island, a continent, or a constellation, as the case may be, as seen through the glass. It will be found that if the glass touches any portion of the equatorial circle on the globe, that a straight line drawn on the glass will represent the curved line of such portion of the equatorial circle as can be seen through it, and another straight line at right angles to the equatorial line will represent as much as can be seen of a given meridian. If a globe is not at hand, some markings like continents or constellations may be cut with a penknife on an orange, so that the white pith, seen when the outer skin is removed, gives the outlines required, and they can be easily traced on a piece of glass held as directed.

To understand the sort of distortion inseparable from such a plan, press a sixpence on to an orange, draw a sharp penknife round it, and remove a circular patch of the outer skin. If the piece of glass is held directly over the centre of the round hole thus made, the tracing will correspond with it in form. Then, keeping the glass still, rotate the orange so that the round hole nearly disappears. If it is again traced in this position, the picture obtained, instead of being circular, will be an ellipse, in which the long diameter will far exceed the shorter one. By cutting out square, oblong, and triangular pieces of skin from the orange, and pursuing the same plans with them, the effects of distortion on different kinds of figures, as seen in different positions of perspective, may be observed. Any body can get an orange and a piece of glass. It is easy to make a set of experiments of this sort, and they would form a pleasant evening's amusement for an intelligent family.

To carry familiar expositions of projections of the sphere a little further, we may have recourse to a gas burner with a globular shade or a moderator lamp. Wafers, or little pieces of opaque paper may be stuck on to the globular glass, and when the lamp is kindled, it will throw shadows corresponding with each one. Pieces of the same shape and size, circles, triangles, or squares, should be placed on different parts of the glass, some near its equator, and others in what we may call different latitudes. If a sheet of white paper is then held in different positions, the shadows thrown on it will correspond with, or differ from, the real shapes of the objects producing them, according to principles which will be apprehended, if the orange experiments have been previously performed and well observed.

The orange may be resorted to again in another way. In-

stead of holding a piece of flat glass over it, let it be held opposite a looking-glass, and rolled so that the reflection of a round hole passes through the changes from its true shape to the slender ellipse and line, in which it is finally visible. The effect of foreshortening one diameter as the circle ceases to *face* the looking-glass is very striking, and may be advantageously compared with the apparent foreshortening of a line of equal diameter cut in the orange, in the same direction as that particular diameter, and a little further off. The eye will will be found far more sensitive to the foreshortening of the circle than to that of the straight line.

If the stars were all laid down on a glass globe, as we see them in our hemisphere when we lie down on our backs, and, looking upwards, perceive the heavens as a great hemispherical vault, such a globe would exactly represent our skies with their stellar lights, if we could get inside it, and look upwards from its centre at the star effigies. Let anyone imagine himself in the centre of such a glass globe, and looking through it at six sheets of white paper, each touching it at one point, and the whole forming a *cube*, holding or circumscribing the sphere. Each star image, if opaque, would just prevent our seeing one spot on one of the sheets of paper, and if anyone made a dot at that part of the paper, and this process were continued until there was a dot for each star, we should then in technical language have obtained a *projection of the sphere on the sides of a circumscribing cube.*

If a glass globe, with stars laid down upon it in opaque dots had a lamp suspended in its centre, and it was hung up and surrounded by six sheets of transparent paper, each one touching it, and the whole forming a cube, the shadows thrown on the paper would map out the stars as well as they could be depicted upon such a principle.

Apart from geometrical or mathematical technicalities, it will be evident that just in proportion as a cube differs from a sphere, so will the attempt to represent the surface of the one or the surface of the other be defective; and it will be most defective at the *corners of the cube* where the difference between the cubical and circular form is most complete.

Now the curved line of a circle would be most nearly represented by an infinite number of straight lines, so arranged as to coincide as closely as possible with the bend of the circle. So a figure with an infinite number of sides might be made very nearly to coincide with a sphere. The simplest flat-sided figure that can enclose a sphere is a pyramid, and the simplest figure, *which has its sides and angles equal,* and is capable of so doing, is a cube; and if it is desired to avoid the distortion occasioned by projecting a sphere upon the six sides of a cube,

and still to have a projection upon the same principle, another figure must be chosen which has more sides than a cube, and which thus deviates less form a sphere. A figure of a great number of sides would be inconvenient, because each side must be embodied in *one* map, and a great multiplicity of maps would be gained at the expense of cutting the constellations into pieces, and presenting too little for recognition at one view. The Useful Knowledge Society's maps, designed by Sir J. Lubbock have the cube as their basis. Mr. Proctor takes the dodecahedron, and thus requires twelve maps for a complete sphere—six for the northern, and six for the southern half. By this plan he lessens the maximum distortion just in the proportion that a dodecahedron is nearer than a cube to a sphere. If maps upon this arrangement were drawn on a large scale the eye could not take in enough at the same time, but, by adopting a small scale he is able to get six maps side by side in one plate a foot square. Thus each plate comprises a hemisphere, and the eye passes readily from the edge of one of his pentagonal maps to the edge of the next one in which the delineation is continued. Each plate has the convenience of a planisphere without its distortion; and this will be found a great help to those who require star maps to assist in recognizing or finding celestial objects, either by going from the sky to the map, or from the map to the sky. The small size of these maps gives the advantage of compactness which is desirable, but it necessitates minute engraving, and hence many students will find it handy to use a hand glass to assist them in making out the details.

The first appearance of a series of pentagonal maps conveys a curious impression, but such an arrangement is both elegant and convenient for use. The plan of the plates will be understood by imitating a diagram given by Mr. Proctor in a well-written explanatory preface. This may be done by drawing a pentagon with five equal sides, say 2¾ inches each, and then from each face of this pentagon as a base, drawing five equal and similar pentagons. Each one of the composite figures thus obtained would represent one of Mr. Proctor's plates, and if two such figures were cut out of cardboard, they could be folded and joined together so as to form a dodecahedron. Mr. Proctor states that "all the stars in the catalogue of the Astronomical Society, down to the fifth magnitude inclusive, are laid down in these maps. The right ascensions and declinations of these stars, about 1,500 in number, have been calculated from the values and variations given in that catalogue. Many nebulæ and stars of the sixth magnitude have been added, and also many stars of the fifth magnitude not included in the catalogue." He adds, "variable stars are marked *var.*,

double, triple, or multiple stars, *doub.*, *trip.*, *and mult.*, respectively.

In addition to the two coloured plates, in which the stars are arranged in constellations, and parallels of declination and right ascension given, there are two "stereo-plates," in which the stars are laid down in white on a black ground. These will be found much handier for comparison with the heavens than the first named maps, and it is very easy when any star has been identified in a stereo-map to find its name by reference to a corresponding pentagon in the coloured maps. As a further convenience, Mr. Proctor has added to his pentagons triangular wings, in which the stars though laid down in greater distortion answer the purpose of enabling constellations at the corners of his maps to be more complete. Stars given in any one of these wings will be found repeated in the adjacent pentagon to which they belong, according to the principle of the projection.

Presuming that Mr. Proctor has carried out his details with the accuracy that may be reasonably expected from the painstaking author of *Saturn and its System*, we strongly recommend them to telescopists as the most generally useful series that have appeared. They are beautifully engraved, and the explanatory preface will supply much useful information as to the nature of gnomonic projections of the sphere.

Before leaving the subject of star maps we must express our regret that the excellent series drawn by Mr. Herschel for the British Association Shooting Star Committee have not been regularly published. These maps were described at some length in our December number (1865), and they are for this special purpose and for certain other purposes, the best that have appeared. They differ widely from Mr. Proctor's, and at the inevitable expense of distortion gives all the stars visible at one time, from the zenith to within from 16° to 25° of the horizon. This is accomplished in twelve maps corresponding with the same hour for twelve months, or with twelve successive periods of two hours each on any given day. In this series the *alignments* are quite correct, which was necessary for his purpose, and as illustrations of the difficulties of celestial map making it is curious to compare the dimensions occupied by such a constellation as the Great Bear in the positions most and least favourable for accurate depiction.

To return to our explanation of the principles of map projection we must call attention to the *point* of projection. In the illustrations we have given we have supposed the glass globe to have a lamp in its centre, and to throw shadows of the stars as projected from the centre upon the sides of any circumscribing figure. It is, however, plain that we might move

the lamp higher or lower. It might journey from the top of the sphere, or its north pole, to the opposite pole, or stay at any intermediate point. Then at the bottom it could throw shadows of all stars from those right above it, down to those only a little above it on a sufficiently large sheet of paper held exactly over the top of the globe. The distortion would increase as the part of the sheet of paper which was able to receive the shadows was further removed from the sides of the globe.

Those who wish to understand the projections of the sphere more fully can consult Sir John Herschel's *Outlines of Astronomy;* Professor De Morgan's *Explanation of the Gnomonic Projection of the Sphere,* and the Preface to Mr. Proctor's *Star Maps.*

ON FISH CULTURE.

A VISIT TO THE PRINCIPAL PISCICULTURAL ESTABLISHMENTS IN GERMANY, SWITZERLAND, AND FRANCE.

BY AN OLD BUSHMAN.

(*Continued from page* 93.)

ALTHOUGH in Bavaria and Wurtemberg all fishing during the spawning season is forbidden, in the canton of Zurich, close time only extends from the middle of April to the end of May, *i.e.,* during the spawning season of the spring fish. The salmon, which spawn in autumn, are consequently not in the least protected; and in many of the Swiss cantons it appears that there are no laws against taking fish in the breeding season.

In the canton of Aarau fish-hatching has also begun; and after inspecting a private apparatus at Thun, in the canton of Berne, Byström proceeded to Geneva to see Dr. Pictet. But it appears that neither of the two fish-hatching establishments, which for some time existed in that city, are now carried on, so he proceeded at once to Nuon, a small town on the banks of the Lake of Geneva, and in the neighbourhood of which Professor Chavannes has opened an apparatus for hatching salmon roe on his estate at Pont Farbel.

The apparatus is constructed close to his dwelling-house, where a spring from the earth, which has a yearly temperature of 8° warmth Celsius, is peculiarly adapted for a contrivance of

this kind. Close to the spring, and under the bare sky, four hatching apparatus are fixed; of which two stand on the ground in a row, and two are placed directly over them. Each box is about fourteen feet long and one foot broad, and not, as is usual, furnished with gratings, but are altogether closed at both ends. The bottoms are covered with layers of gravel one inch high, and the water, an inch deep, circulates over the gravel, and runs out through small tubes of block tin. This invention has the peculiarity to lead the stream of water not on the surface, but as near the gravel—and consequently as near the eggs—as possible; for here they lay the fructified eggs immediately upon the gravel beds in the boxes.

Regarding the fructifying of the roe, Professor Chavannes has made the following observation:—That the roe, which in the winter is fructified in cold water—for example, in 4° warmth Celsius—does not give such good results as that which is fructified in a temperature of 8° warmth. Consequently, if the water in which he operates becomes lower than 8° warmth, by a mixture of warm water he attains the required temperature.

Professor Chavannes plants out the greatest number of his young fish—principally lake trout—in the Lake of Geneva, as soon as the umbilical bladder has disappeared. He receives from the crown a stipend of 800 francs, and the right of fishing in a small stream near Eranson, at the south end of Lake Neufchatel. Lake trout come up this stream every autumn from Neufchatel to spawn; and it is from these fish that the professor obtains the roe for his apparatus. Although he yearly turns such a quantity of young fish into the Lake of Geneva, that lake is so large that scarcely any apparent results can be observed. He has even attempted to acclimatize salmon in this lake; and out of 300 young salmon which were turned out three years ago, about thirty have been taken in different parts of the lake, the largest weighing about 2 lbs. How the experiment of turning out the true salmon into the Lake of Geneva will answer, remains to be proved.

Many of the young fish are even fattened in streams, and for this purpose the Professor has made a feeding canal below the hatching boxes, about 260 feet long, two feet broad, and eight inches deep. Only the sides of this are boarded; the bottom is formed of the ground itself, and is partly covered with grass. This canal, which is divided into three compartments by gratings, contains partly altogether cold water after it has run through the hatching boxes, and partly brook water which is brought from a stream in the neighbourhood. In the first compartment, which is covered, between 100 and 200 young salmon, about eighteen months old, but varying exceedingly in size, the largest being probably six inches long, are preserved.

They are fed partly with ox melt and liver, partly and principally with worms cut into pieces. In both the other compartments were to be seen young trout, of one year and half a year's age; but only a few, because the greatest part had escaped by the sides, which were not tight. Professor Chavannes said, that for the first year, at least, the young fish required no other nourishment than they could obtain for themselves in the open and grass-grown canal; for here were lots of small crustacea, which form by far the best and most natural food for the young *Salmonidæ*.

He now sought out the establishment of Prof. Dr. C. Vouga, living in the village of Cortaillod, two hours' journey south of Neufchatel. This is on a smaller scale, and formed in the lower portion of his house, which in summer is used as a bathing-place for invalids, and in winter for fish-hatching. The great lake trout come up a stream which runs close to the doctor's house, from the Lake of Neufchatel, every autumn, to spawn; and it is the roe of this fish that he fructifies and turns out into the lake. Formerly this river gave a yearly return of 60 to 70 cwt. of fish, but has now dwindled down to 10 cwt. The lake trout which are taken here seldom weigh less than 8 lbs., and often reach 16 to 20 lbs. The Doctor receives a small yearly stipend from Government of 800 francs.

His method of extracting and fructifying the roe was original. As soon as he fancies the roe is perfectly ripe, a servant takes the fish, and wrapping a linen cloth round it, holds it under his arm; he then himself grasps the tail of the fish, encircled with a linen cloth, in his right hand, and, holding the fish in a slanting position with his left hand, presses as much roe from it as is ripe. The fish is then put back again into the reservoir, and after three or four days the operation is repeated; but instead of letting the roe fall direct into the water, as is usually done, he lets it fall into a clean, dry vessel, and when a sufficient quantity is spread out on the bottom, he pours as much water on to it as will cover it. He then presses out of a male fish, which he holds in the same manner, a few drops of milt, so that the water, when stirred up by the hand, shall be slightly coloured. After about a minute, he pours away the water, and replaces it with new water, and the roe is then transferred to the hatching-boxes. This plan, which he learned of a Russian, has produced the best results. Full, ripe, and well-fructified roe has returned him sixty per cent, of fresh young fish; whereas, at Hüningen, they rarely reckon on more than twenty-five or thirty per cent. In the first year he slipped out into the stream 20,000; and in the second year (1862), 80,000 young trout. He turns them out in March, as soon as the umbilical vessel has disappeared. He also fed up

some fish in dams, but as the dams were filled up with grass, and too much exposed to the sun, the fish died by hundreds. The Professor fancied, that for the first year the young fish require no other food than they can take themselves, and that 1000 young trout had room enough in a dam of thirty feet length, eight feet breadth, and one foot depth. In another dam, not very large, but eight feet deep, he had some two and three-year old trout, the latter weighing about 1 lb. He fed these with ox milt, and lungs, and worms. In the winter they required little or no food, and even in the summer they were sparingly fed; but when they got more meat, a lake trout of two years old would reach a weight of 1 lb. He was just about forming a compost of layers of ox blood, rotten leaves, and earth, in order to breed worms on a large scale, to be used as food for the fish.

From Cortaillod, Byström proceeded to Soleure, where a private gentleman, one Franz Vigier, had upon his estate, Malsenhof, about seven hours' journey from Soleure, formed a fish-hatching and feeding establishment of lake trout, from which he derived a considerable income. His process was on the same plan as that of Kuffer, in Munich. But at first the hatching process did not answer. It was carried on in boxes, under the bare heaven, and in canals, in the same manner as at Meilen, near Lake Zurich. But here the plan did not seem to answer, for his roe never returned more than twenty-five per cent. of young fish. The least defect in the fine lattices, or the very least opening which may be formed by the water in any part of the dams, used either for hatching or keeping the young fish, is sufficient, in a few hours, to let thousands of the young fish escape. During the last winter, 23,000 young lake trout and trout had been hatched out.

The feeding dams were supplied with the same water as the hatching apparatus. They were oval in form, about a hundred feet long, fifty broad, and the greatest depth was seven feet.

In the upper dam were 500 trout, of one and a-half years old, and about five inches long. In the second dam were about 600 trout, two and a-half years old, of six to seven inches length. In the third were 300 fish, four to five years old, nine to ten inches long. The principal food supplied to these consist of snails, collected in rainy weather; but these could not always be procured, and then the fish must content themselves with such food as was to be found in the grass at the bottom of the dams. There was no lack of grass here, for the dams were nearly choked up with it; and Herr Vigier thought that this vegetation was very useful to the growth of the fish, as providing them with a great deal of food in the shape of small

water insects. But it is pretty clear that the young trout thrive much better in smaller dams, where there is a good current of water, and whose bottoms are free from grass, but covered with fine clean gravel, and, moreover, where the fish receive a daily and even supply of more truly animal food.

Herr Vigier had—as well as the before-mentioned Dr. Stephan, whose dams were also filled with grass—made this observation, that not so few of the trout which were fed up in the dams were blind. He had also observed that many of these trout, from which he had taken roe for artificial hatching, in the next year had no roe. The cause of this must have been the poor and irregular supply of food.

About the end of October he visited Basle, and called upon Herr Glaser, who supplies most of the salmon and trout roe to the establishment at Hüningen. He had already a considerable number of fish confined in sumps, waiting till the roe was fit for pressing out. These sumps were about four to six feet long, one foot broad, and six inches deep, the sides perforated with holes. They were kept floating in the middle of a timber float, consisting of four large spars, and which were placed out by the side of the broad and rapid Rhine. In these sumps the fishermen can keep the fish confined for three or four weeks without any injury to the roe, which becomes ripe during that period; but besides trout, there were two large salmon, which had been fastened to these timber stocks for fourteen days by a strong line, which was drawn through the mouth and one gill opening, and there fastened. This method, which is even recommended by some of the French pisciculturists, did not, however, answer here, for the female died before the roe was ripe, and it constantly was of no use. The usual time for commencing fructification was well in, but it appeared that on this year it was later. They tried with two trout; but as the roe or milt could not be ejected without a strong pressure, it was doubtful whether any good would follow. The method of fructifying was as before described. Glaser fancied that all the roe corns in a fish were ripe at the same time, and he therefore, for fructification, pressed out all the roe at once; and he had also remarked that the roe of small fish artificially fructified, in general gave much better results than the roe of large fish.

From Basle, across the French border, to the little town of Hüningen, was his next stage, to inspect the large piscicultural establishments belonging to the French Government, about one hour's journey from that place. This was built in 1852, upon a plan of Prof. Coste, in Paris, at a cost of 30,000 francs; but it has since cost a great deal more.

The establishment is constructed on an even plain, and is

bounded on one side by the Rhine canal, which commences at Hüningen, and on the other by a steep height. The buildings are capacious, and well laid out. The floor on which the real hatching apparatus is placed is sunk into the earth to the depth of several feet, and a sufficient light is admitted by large and close windows in the sides of the shed. On the plain round about a number of dams of different sizes are constructed, containing pike, perch, and several of the carp genus, which breed in the grass, and are used as food for the artificially-hatched salmon. All these dams are supplied with spring water, partly from a brook which runs through the plain, and partly by water from the Rhine, which is brought down from the great Rhine canal to the hatching-houses, by a smaller side canal, about 4000 feet long.

The water for the hatching apparatus is supplied from some abundant springs at the foot of the above-mentioned heights, and is carried down by a well-built underground canal, of about 2000 feet long, into one of the side buildings. Here it is divided into three canals, parallel with each other, of about two feet broad, running along the whole length of the floor, and thence to the bottom of the building. These canals then join into a single one, which runs through the other end of the building, and at length, mixed with water from the canal, empties itself into the excellent dams which are used as depositories for the newly-hatched salmon and trout fry. In the above-mentioned canals, the bottoms of which are covered with gravel, small gratings are laid down to place the hatching boxes on. These are eighteen inches long, six broad, and are placed in rows of four throughout the whole length of the canal; and by rising or sinking the lattices it is always contrived that the roe shall lie in water one inch deep. But even between these canals others are constructed, which are filled with smaller hatching-boxes; and in the first building several other boxes are ranged over the canal, formed of polished earthenware of a light yellow colour, twenty-one inches long, six inches broad, and five inches high, and which are supplied with water by machinery from below.

To fill these immense quantities of boxes with roe, of which each one holds about 2,000 corns, engineers have been sent to Switzerland, North Austria, etc., to teach the art of fructifying the roe; and by this means the establishment yearly receives seven millions of roe corns. Besides this, a great deal of roe of the Gwinniad (*Coregonus fera*) comes from the Lake of Constance. But this is not hatched in separate boxes, it is only spread out on the grass in the dams, and in this manner has not led to any great results.

Much of the roe is sent away, often to great distances

from the establishment, and sold at so much per 1,000, according to the species. It is never sent away before the eyes of the embryo are visible. According to the engineer Petch, during the last year no less than four millions of roe corns had been distributed to private individuals, besides 300,000 to 400,000 small fry. They reckon that out of the fructified roe, at least fifteen per cent. is utterly worthless, but of that which comes well to hand, twenty-five to thirty per cent. of fresh young fish can be calculated on.

For the transport of the young fry from Hüningen they use round tin jars, ten inches high and nine inches in diameter. These are half filled with water, and furnished with a pipe perforated with small holes fastened to the bottom, through which air is mixed with the water. This pipe is formed like a funnel at the top, so that when the water is changed, it can be poured into it, and the inflating it with air is managed by a separate apparatus. In such a vessel 3,000 young fry of three months old can be easily transported, if only the water is changed every third hour.

Attempts have been made to feed up the young of some of the species of salmon in the before-mentioned dams, but they have failed; probably on account of the flat nature of the country, and a want of good streams, in which alone salmon will thrive.

From Hüningen he proceeded to Paris, to inspect the hatching apparatus of Professor Coste, in the College de France, and which is upon the exact principle of that at Hüningen. The water is always kept during the winter at an even temperature of 8° warmth Celsius.

Another apparatus, that of Herr C. Millet, is also worth inspection. He principally turns his attention to the fish indigenous to the Seine waters. He has used with good success an apparatus of prepared canvass sunk in the stream itself, in which many millions of roe corns have been hatched. And for carp, bream, roach, he makes proper places in the dams for spawning with bushes, grass, and the like. For bream and roach he simply provides a sump, round the inner sides of which he places small branches, and confines the male and female fish before the spawning time. As soon as this is over, he lets out the fish, and hides the roe which has been laid on the branches, in some place secure from enemies.

Even for lake trout and *S. lembla*, which spawn on gravelly places, it is easy to form natural spawning beds. If it is wished to cultivate these fish in smaller dams, with muddy bottoms, it is only necessary, here and there, to form small beds of gravel or small stones, rake them well together, and dig small furrows in them.

Herr Millet considers that to hatch the fructified roe of the genus salmon requires a temperature of 3° to 10° warmth Celsius. He says that the fructifying power of the milt of trout lasts only half a minute after coming in contact with the water, and that this in most fish lasts from about one to two minutes. He is therefore opposed to the method which many adopt of mixing the milt with water before the roe is pressed into it, because the pressing out of the roe is sometimes a tedious operation. In practice it is not good to take the milt from a dead male fish, although the roe which is taken from a dead female often fructifies well. In fructifying the roe, it should not be exposed to cold and drying wind, nor to strong light. The anus of the fish should be held, if possible, under the water, and if the roe will not come easily, it is better not to force it. If the fructifying cannot well be carried on at the water's edge, or if the roe is not quite ripe, the fish may be kept captive in the water by means of a line passed through one of the gill openings and the mouth, or else tightly encircled in a net; but it should not be kept too long a prisoner.

The artificial fructifying of the roe of carp, roach, etc., must take place on small branches, or water-plants; and the roe of tench and carp require a temperature of 25° warmth Celsius.

The best apparatus for hatching roe is a double strainer of prepared canvas, or galvanized metal, furnished with a float, which can be sunk at a proper depth either by the side of a river or lake, and unclean or bad milt will pass away through it. Wood, zinc, or block-tin may be used in the construction of these apparatus; but copper and such metals must be avoided, on account of galvanism or electricity. This canvas strainer can also be used for the transport of fructified roe, laid between damp cloth, damp paper, and damp moss, will prevent it shaking and rubbing.

Millet fancies that the number of fish can be increased a hundred-fold in comparison with what it is now, through a good method of pisciculture and a good water police. The science of pisciculture in France is yearly spreading, but at present in the large waters no very great results have been observed. But now the bailiffs for the forests and waters have made an excellent regulation. Basins have been dug by the sides of many of the large streams, which, furnished with two canals, the one for the ingress, the other for the egress of the water, are connected with the stream, the fish of which it is wished to preserve. During the spawning season the fish can enter these basins and deposit their roe on artificially constructed beds. Great complaints are made of the damage which the sewers in the Thames every year do to the fish

spawn. Now, such canals and basins by the side of this river, would effectually protect the roe at least from the swans. Directly after the spawning is over the sluices might be closed, and not opened again until the young fry have gained a little strength to protect themselves when they seek the waters of the river. Not less than eighty such basins, spread over thirty-five departments of France, are already in working, the cost of which has been about £1000. In 1861 it was calculated that about six millions of young fish had been turned out of these basins. The taking of all fish during the spawning season, except for the purpose of fish culture, in France, is strictly forbidden.

It will be seen, from a perusal of the above, how far before England continental countries stand in the development of pisciculture, one of the most important branches of science, and one which is of so much practical utility.

PLEASANT WAYS IN SCIENCE.

No. IV.—Physical Forces.

In some writings, a distinction is made between physical and chemical forces. In this place, all the forces exerted by matter are designated under the appellation *physical*, and the first inquiry we shall suggest relates to the sort of information we can obtain concerning the objects by which we are surrounded, and which exert different kinds of force. The present popular philosophy conceives of matter under the dominion of laws external to itself. It supposes that the earth moves round the sun, and the moon round the earth, by virtue of impulses from without, communicated in a precise manner, according to rules prescribed by the laws of gravitation and centrifugal force. The old schoolmen considered matter as capable of separation from its properties and qualities, or, as they called them, its *accidents*. Thus, if a piece of iron were hard and heavy, they conceived of these properties as of something superadded to, and capable of being removed from, the substance itself. The Romish doctrine of transubstantiation illustrates the old mode of philosophizing, as those who gave a scientific form to their belief in that doctrine thought that the *substance* of the elements was changed, although their accidents or physical properties remained, and attached themselves to the new materials, supposed to be miraculously made present.

The popular unscientific thought of our days fails, in an

analogous way, to see that the properties of a substance are inseparable from its existence; that they are, in fact, the necessary manifestation of its existence, under certain conditions. The use of common names for things capable of existing under diversified conditions may encourage fallacious ideas concerning them. Thus, if the term *water* is applied to steam and ice, as well as to the liquid usually meant by that appellation, we are led to the conclusion that water may be solid, liquid, or aëriform. If, indeed, any one called steam or ice, *water*, it would strike others as a mistake; but if the same person affirmed that water was capable of existing in the three conditions just specified no objection would be made, although it is scarcely correct to say that steam is a form of *water*, that appellation being already appropriated, and having quite enough to do to designate a chemical composition of hydrogen and oxygen in one particular state. If the chemical symbol H O designates such a compound, then it becomes quite correct to say that steam, ice, and water are three conditions of H O. If the difference between steam, water, and ice lies simply in the varying degrees of distance by which the atoms of H O are separated from each other when heated to different degrees, and if the degrees of the heating necessary to produce such changes of form under a given pressure were indicated by the letters A, B, C, then A H O, B H O, and C H O, would be the symbolic names of three distinguishable things, and it would be found that, whenever (under the given pressure) H O was heated or cooled to the extent represented by A, B, C, it would always exhibit precisely the same properties.

There is no reason for supposing that these, or any other properties of matter, are *stuck on*, like the so-called ornaments with which London builders disfigure houses, and, like such ornaments, have nothing to do with the main construction. On the contrary, although, by effort of imagination, we might conceive of matter which did not, and could not, in any way act upon other particles, and was not, and could not be, in any way acted upon by them, we should in vain try to discover any particles in such a state. A substance destitute of properties, but capable of receiving them, is also conceivable or imaginable; but it would not conform to anything known, or reasonably expected to arise in the order of nature.

We should have no ground for surmising the existence of matter if matter did not exert *force*, and the force which we believe it does exert furnishes little, if any, ground for conjecturing what matter really is. The "extreme" doctrines of the Idealist metaphysicians, that objects are nothing but our sensations, and the laws which connect them "have not," as

John Stuart Mill says, "been generally adopted by subsequent thinkers; the point of most real importance is one on which those metaphysicians are now very generally considered to have made out their case, viz., that *all we know* of objects is the sensations which they give us, and the order of the occurrence of those sensations." All these sensations arise from the exercise of a power or *force*.

If we observe that one object attracts or repels another, and that one or both change places under this influence, our sight, if not deceived, gives us, so far as its action goes, positive information of what occurs, and we can try the question of whether or not it is deceived, by means that were suggested in an earlier paper of this series, in which motion was considered. In these cases we have ascertained that two things presenting certain appearances have exerted, and been acted upon, by a force, and have moved in consequence. Sight does not, however, give us any information as to what matter itself is, or what force is. It enables us to perceive form, colour, light, and shadow, and thus permits us to recognize objects that have distinguishable forms, or which act upon light in particular ways. When we *see*, a force has been exerted, through our eyes, upon our nerves and brain; and through the action of this force we are led to believe in the existence of an external thing, though what that thing is in its essence we cannot say. We may, however, describe it by its properties, and show, by difference of property, whether of kind or degree, in what respect it differs from some other thing, whose existence we become cognizant of in an analogous manner.

Touch enables us to ascertain the existence of many external objects, and if any one receives a painful blow from a stick he firmly believes in the solidity as well as in the existence of the instrument by which he is struck. But the sensation of a violent blow may be given by an electric shock, and when an electrician who was annoyed by rough fellows swinging upon iron chains in front of his house, made arrangements to give them the benefit of a shock, they fell to quarrelling, each one declaring that the other had given him a blow.

If a ball moves because struck by another ball, or by a billiard cue, the mode in which the force is communicated appears palpable; but a strong electric repulsion will cause a ball to recede although nothing appears to touch it, and a strong attraction will bring it towards the attracting body as certainly and as swiftly as if it were pulled with a string. When two bodies meet one another, each acts in proportion to its mass, and both will move proportionately, if both are free. When two visible bodies rush together under the impulse of

electrical attraction, one part of the process, the motion, strikes our attention; but when hydrogen and oxygen are mixed in certain proportions and ignited, we do not see their atoms rush together, although if the process occurs in a close glass vessel, the water drops on its sides proclaim that they have done so, and exhibit the result.

In the case of the ball moving because struck with the billiard cue, an external force has caused it to change its place; and this is so when the light is applied to the mixed gases and their atoms coalesce and form water under our eyes. Heat was at one time considered as a substance to be added to or taken away from another substance. Electricity was so regarded in the Franklinian hypothesis; and light, according to the theory endorsed by Newton, consisted of extremely small particles shot forth by luminous bodies with enormous rapidity. With greater support of evidence heat, light, and electricity are now regarded as *modes of motion*. If a piece of iron is put in the fire, the burning fuel, that is to say, a quantity of particles in motion, set up a motion in the iron particles. When this has gone on to a certain extent, the iron becomes red hot; it is able to set other particles in motion and waves of light and heat proceed from it in all directions. When we ignite the mixed gases we communicate heat motion to their particles just as we communicated common motion by striking the ball. For heat or light waves to be propagated there must be a material capable of being thrown into the right sort of motion, and if there were a real vacuum or spot in which absolutely nothing existed, neither light, nor heat, nor electricity, would be able to traverse it. Mr. Gassiot has obtained a vacuum too perfect for the transmission of electric currents; but light and heat, both vibrations of matter, however attenuate, pass through any so-called vacuum we are acquainted with; and although we may *imagine* a place in which nothing exists, no such place has ever been discovered, and could we find it, we should only recognize it by its *negative* properties, as a piece of nothing could not be caught and subjected to positive investigation.

Resistance to pressure is a form of force which commonly makes us acquainted with the presence of matter. If we were able to walk, as ghosts are fabled to do, through walls and wainscots, we might, so far as the sense of touch and experience of resistance could inform us, be utterly ignorant of the presence of the bricks and boards. Popular philosophy embodies the old notion that two things cannot be in the same place at the same time, but both optics and chemistry *appear* to contradict it. Thus light rays can go and return simultaneously through what appears to be exactly the same path, without jostling one

another, and they realize something like the conception of the old scholastics who thought that millions of angels might dance on the point of a fine needle without touching each other. If we have a vessel filled with water, it will not hold a drop more at ordinary atmospheric pressure, and *very* little more with any pressure we can impart. There, however, is still room for great quantities of ammoniacal gas,* and when it will hold no more of that, room is still left for various solids which the solution can dissolve.

A process of solution is an exertion of force. A lump of sugar possesses so much cohesion that it is broken with difficulty. Its particles are, however, soon pulled apart by water, and it is dissolved because the attraction of the water particle for the sugar particle is greater than that of the sugar particle for its neighbour.

Partly from education, and partly from a natural tendency of the human mind, we associate the idea of matter with that of force. It is, however, *possible* to conceive of force without matter, or of matter without force. Probably, matter and force are inseparable; and whenever a particle of matter changes its position, or undergoes any kind of motion, a particular force is exerted as the result. It is quite clear that if it exerted no force—that if it did nothing, not even resist force—we could not have any reason for supposing matter to exist; and the tendency to believe that our sensations are produced by objective realities is the chief, if not the only, reason why the manifestation of force is taken to be a proof of the existence of matter. The uneducated mind supposes the thing to resemble the sensation it produces. It can only fancy that a red thing can produce a red sensation; and yet we find that the redness is not essential, and cannot be manifested in blue light. We further find reason to believe that the system of wave motion, which affects us with the sensation of red light, might call up a quite different sensation in beings differently constituted. What we call the redness of a rose—that is to say, its power of reflecting waves that give us the sense of red light—though *seen* in action by us, might be *heard* by some other creatures, and smelt or tasted by others, having organs of sensation differently constructed from our own, or having brains translating the same kind of vibration into mental impressions of a different kind. There might be creatures who taste light, smell sound, and hear a concert when they frequent a garden of odour-giving flowers.

Physical science has no means of tracing the origin of

* The addition of the ammoniacal gas produces a slight change of bulk. Ammonia solutions having a rather less specific gravity than water. This slight change does not affect the argument.

matter or force. Knowing the sequence of events in the formation of a stratum, or the growth of a tree, it can affirm from present appearances certain previous facts, out of which the existing facts have arisen, but it knows nothing of the birth, or the bridal, of matter and force, and speculations on such themes belong to the metaphysician, the poet, or the divine.

Force may be inherited. A large mass of fluid, twirling round with great swiftness, may be broken up into smaller masses, each one inheriting from the parent mass a portion of the motion which belonged to it as a whole. A river falls over the brow of a stupendous cliff; as it descends, it divides and divides again, until, if the descent be long enough, the once-coherent fluid is scattered into myriads of disunited drops of spray, each one of which inherits its share of the family property of motion originally communicated to the river as a whole. The centrifugal motion of planets may have been inherited from movements once belonging to nebular and condensing masses, from which they may have been derived.

No mass, no particle, can approach or recede from another mass or particle without exerting a force, or changing the resistance to an existing force. Every fragment of material we can hold or see is a storehouse of force. In the case of certain compounds like gunpowder, we know how to unlock chemical forces of affinity and cohesion, and to obtain, by a sudden expansion and rearrangement of atoms, a mechanical power that rends the rock or propels the ball; but it is startling to think that the most quietly behaved bodies we find on the globe, the granite frames of mountains, or the very dust particles on the road, are like sleeping lions, full of *potential* force, which they can give out the moment the balance of their affinities is disturbed.

The amount of force exerted at any given time depends upon the quantity of material in motion, and the energy with which that motion is performed. When heat and light waves are propagated from the sun to the earth, the quantity of matter in the ether between us and our great luminary concerned in transmitting those wave motions, which, beginning in the sun's body or photosphere, reach us with a power sufficient to snatch myriads of tons of water from the ocean, and compel myriads of tons of carbon to arrange themselves in the forms required for vegetable growth, is so small, that our imagination fails to grasp the notion of its tenuity, but the energy of its movements makes up for the smallness of its quantity; and all the men that ever lived upon the earth could not have counted, had they spent their whole existence in the task, more than the minutest fraction of the waves of light

and heat that strike, in the course of a few minutes, upon the humblest plant. No force that we are acquainted with as operating within the system to which we belong at all approaches sun force in its various forms. When it gives light and warmth in different proportions to enormously distant bodies, and causes in all innumerable transpositions of matter, it uses as a medium for the conveyance of its powers that ether fluid, so subtle, that we only experience a pleasant sensation when its waves dash against our cheeks with a velocity so great, that the swiftest mechanical motion beside it seems still. In another paper we must consider the doctrines of the correlation and conservation of force, to which latter Mr. Grove has contributed so much excellent thought and illustration. But if gravitation bears any resemblance to heat force, light force, or electric force, then, astounding as it may appear, it may prove that, through the same impalpable ether, the sun transmits the attraction which keeps his planets around him, and compels remote Neptune to curve his far-off wanderings back to their appointed place.

DECEPTIVE FIGURES.

Our attention was recently called to an optical delusion with which, we are told, practical masons are familiar, and of which they have to take account in arranging certain ornaments of stucco or stone. We find, however, from experiments made with various persons, that few are acquainted with it, and as it will afford amusement and at the same time illustrate certain principles of vision, we beg to introduce it to our readers.

Two pieces of card should be cut and arranged, as shown in Fig. 1 of the annexed plate. If shown to any one in the position indicated, and the question is asked which of the two is the largest, the answer will be "B, to be sure." A should then be placed under B, still forming the figure as shown in the plate. This will cause it to look longer than B, and the two should then be placed so that one covers the other, and they will be found exactly the same size.

Fig. 2 exhibits a similar optical deception; whichever is uppermost looks the smallest, but C and D like A and B are the same size.

A and B may be placed in the position of C and D, and the upper one will then look the smaller of the two, though this form of the delusion is best shown with the patterns C and D. Reversing the curves changes the effect.

Fig. 1.

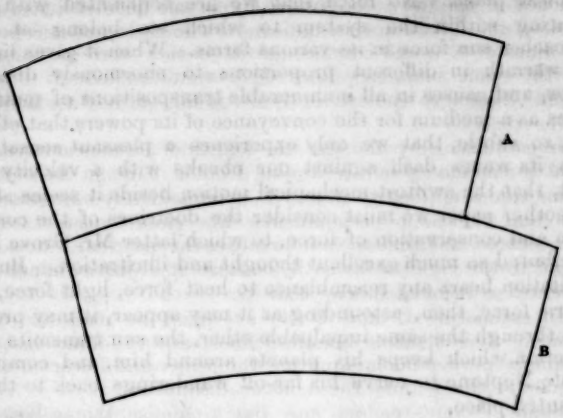
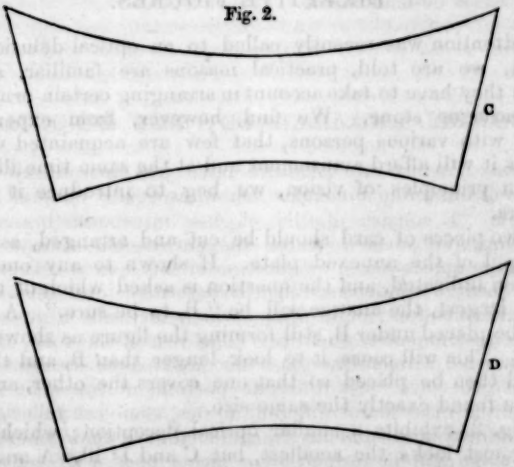


Fig. 2.



DECEPTIVE FIGURES.

The *rationale* of the deception shows it to arise from the tendency of the eye to be guided by simple decided lines, and to follow the direction they indicate. The right and left boundary lines of C would cut through D if they were prolonged, and the same boundary lines of D would include C if prolonged; therefore the eye or brain is misled, and we fancy C smaller than D.

In estimating by the eye the length of circular curves, we ought to commence our reckoning from a point in the centre. If this rule is applied to A and B, it immediately becomes evident that the same perpendicular line cannot pass through their centres, and thus the mind realizes the fact that A does not extend to the right as far as B, because it is just as much out of centre as it looks shorter than B.

In estimating C and D the eye must be made to avoid following their slanting boundary lines, and to follow, instead, imaginary perpendiculars uniting the upper and lower corners. As soon as this is done the delusion disappears.

Some of our readers may like to amuse themselves by inventing analogous means of deception, and with trying what action this curious effect of leading or misleading lines may be made to have in ornamental designs, or what allowance must in some cases be made for it.

POWELL AND LEALAND'S NEW BINOCULAR.

Messrs. Powell and Lealand have just introduced a new mode of obtaining binocular vision, especially adapted to high powers. It consists of a flat of glass interposed in a slanting position, and so as to catch the entire cone of rays coming from the object-glass. A portion of this cone is reflected as in their form of condenser recently described, and then suffers a second reflection from a prism, which forwards it up one tube of the instrument to the eye. The rest of the cone of rays is transmitted *through* the glass flat, and passes straight onward to the other eye. As different portions of the cone of rays strike the glass flat at different angles, some are reflected more than others, and some are transmitted more than others. Thus, one image will be formed by a larger portion of central, and the other by a larger proportion of peripheral rays, and this appears to give as much difference as is requisite to produce a stereoscopic effect with *high* powers, for which the apparatus is specially devised. The circulation of the valisneria is beautifully shown by this method with a $\frac{1}{16}$th, and with the same

power we have seen the two sets of lines in that most difficult object, the Amician test, finely displayed.

When lower powers are employed, Messrs. Powell and Lealand remove their peculiar arrangement of the field, and substitute Mr. Wenham's prism. Their plan is, therefore, a valuable *addition* to that of Mr. Wenham, and not a substitute for it. The separation of the cone of rays into two halves by the new plan is quite free from any action of *diffraction*, as no solid body like Mr. Wenham's prism is introduced into the cone, and made the means of its division.

With the two arrangements of Mr. Wenham and Messrs. Powell and Lealand both elegantly arranged in the same slide, microscopists seem provided with all that they can desire, and no severer test could be tried than the Amician diatom, whose markings we have alluded to as well displayed. The new plan can be adapted to any good binocular instrument.

ARCHÆOLOGIA.

A very singular Discovery of Human Skeletons was made in the earlier part of the last month, and deserves recording. Milcote, or Millcott, is a hamlet belonging to the parish of Weston-on-Avon, in the county of Gloucester, although it is enclosed in the adjoining county of Warwick. It occupies an angle of land formed by the confluence of the Stour and the Avon, and is between two and three miles from Stratford-on-Avon. In this hamlet there is a grass-field of about four acres, at a place named Clifford Chambers, in which from time to time human bones have accidentally been dug up, and this circumstance had given rise to a story that it had been the scene of a battle with the Danes. This has been for some ages a common way of explaining the discovery of remains of the dead under such circumstances. The sub-soil of this grass-field is gravel. At the period mentioned above, the farmer who occupies the land was in want of gravel, and, knowing that he would find abundance of it under the grass-field, began digging there. At a depth of about eighteen inches beneath the surface, the workmen came upon human skeletons lying regularly arranged in rows. In a space of forty-four feet by eighteen, no less than thirty-nine perfect skeletons were found; and if, as is supposed, the skeletons extend over the whole field, or even over one half of it, the number of interments would amount to several thousands. The bodies appear to have been carefully laid in regular rows, rather close to each other, the bodies lying in a direction east and west, on their backs, with the arms generally crossed over the pelvis. Medical men who have seen these skeletons pronounce them to be those of males in the vigour of age, and some of the skulls are said to

be cut or broken in, as if by the blow of a heavy weapon. Unfortunately, no objects whatever which might give a clue to the date of these interments, weapons, coins, pottery, or any other articles, have been found in the field; and we have no direct historical information which can throw any light upon the subject.

The only suggestion which has been offered on the subject is that these skeletons are the remains of men slain in the baronial wars of the reign of Henry III. Evesham, near which the great battle was fought in which Simon de Montfort perished, is only ten miles from Millcote, and it has been conjectured that a portion of the defeated troops, flying along the vale of Evesham, had been overtaken at the confluence of the Stour and the Avon, and slaughtered and buried there. In reply to this, however, it must be remarked that it would be very extraordinary if there should have been such a circumstance of that celebrated battle, attended with so considerable a slaughter, and that it should have been overlooked by the rather careful chroniclers of those events. Moreover, it was not usual to bury the dead after a battle in this regular manner. Some years ago the depository of the slain from the battle of Lewes, fought in the year before that of Evesham, was found. There an immense and deep pit had been dug, and the dead were thrown in pell-mell and then covered up. The only case we remember at all resembling the one of which we are now speaking, is that of the skeletons in a field at Wroxeter, which furnished the deformed skulls, and which were supposed to be the remains of people slain at the time of the capture and destruction of the Roman city of Uriconium. They, like those at Millcote, were arranged in parallel rows, and were laid upon their backs with their arms crossed over them, and with them, similarly, no objects were found which appeared to have belonged to them to fix their date. They probably belong to a rather remote date, but the field lies in rather suspicious proximity to the church, which was one of early date, and they may only mark the site of a mediæval cemetery. Such also one might be inclined to suppose was the character of the field at Millcote, only it is difficult to imagine that a cemetery of such extent, and containing such an enormous number of interments, should have been so entirely forgotten.

Some very interesting Mural Paintings have recently been discovered in the church of Cliffe, in Kent. In the middle ages, the interiors of churches were not only ornamented with sculpture, but they were richly decorated with paintings, and sometimes with gilding also. The Roman practice of decorating the walls of the rooms in their houses with fresco-paintings, was at an early period adopted by the Christians in their churches, and while the columns and architectural ornamentation were covered with gilding and painted with rich colours, the flat face of the walls was painted, no longer in fresco, but usually in distemper, with subjects taken chiefly from the Scriptures or from saints' legends. In many cases the effect must have been gorgeous to a degree which we can hardly now understand. After the Reformation, this kind of ornamentation fell into contempt, and that which existed was regarded, on account of

many of its subjects, as at least Papistical; and, without taking the trouble to destroy it, people covered it with whitewash, layer after layer in course of time, until it was sufficiently protected from outward violence. In the course of modern restorations and alterations, as the whitewash peels off with tolerable ease from the old surface, many of these ancient paintings have been brought to light, but in too many cases they have been destroyed almost as soon as uncovered. They have often received so much injury that they cannot be preserved on the walls, but in all cases it is desirable at least to have careful drawings of them made and preserved, for they furnish very interesting illustrations of mediæval legend as well as of mediæval art. The paintings recently discovered in Cliffe Church represents the story of King Edmund the Martyr, told in five compartments, and is of rather early work, ascribed, we believe, to so remote a period as the thirteenth century. The first compartment represents King Edmund on horseback, surrounded by his enemies. The second represents his martyrdom; the saint is tied to a tree, and shot to death with arrows. On the third, one of his enemies is cutting off his head. The fourth represents the wolf, according to the legend, carrying the martyr's head to his friends, who wanted it to bury with the body. The subject of the fifth compartment is the burial scene. We are glad to say that, by the agency of the incumbent, the Rev. E. H. Lee, the remains of this curious wall painting have been carefully preserved.

The Archæological Societies are *now* making preparations for their annual congress in the summer or autumn. The Archæological Association will meet at Hastings, and we believe that everything promises a very successful meeting. The Archæological Institute proposes to meet in London, and they have announced the intention of forming a prehistoric section, over which it is understood that Sir John Lubbock will be selected to preside.

Programmes have been sent round to a few of the more distinguished antiquaries of different countries, inviting them to an International Archæological Congress, to be held at Antwerp, opening on the 12th of August next, and closing on the 21st of the same month. This meeting has been organized by the Académie d'Archéologie of Belgium, in concert with the French Archæological Society. The invitations come direct from the Belgian Académie, under the signature of its president, H. Vande Velde, and the whole plan appears under the guarantee of the names of the first archæologists in Belgium, with the name of the Minister of the Interior, M. Vandenpeereboom, as the honorary president, and MM. le Chevalier Pycke d'Ideghem, Governor of the Province of Antwerp, and Van Put, Burgomaster of the town of Antwerp, as honorary vice-presidents. It is a special characteristic of the plan of this congress that no papers are to be read; business of the different meetings is to consist entirely in the discussion, between the representatives of archæological science from the different countries of Europe, of a rather long series of archæological and historical questions, which are enumerated in the programme, and on which it is considered that new light may be thrown by such a personal conference. Other questions

not enumerated in the printed list, may be brought forward under certain regulations. Scientific excursions also form a part of the plan of this International Archæological Congress. T. W.

PROGRESS OF INVENTION.

ELECTRIC REGULATION OF TEMPERATURE.—Many modes of regulating temperature have been adopted, with more or less success. Electricity is now applied to this purpose, and the results obtained, by means of it appear to be everything that can be desired. The apparatus used consists of a thermometer, into the bulb of which is hermetically sealed a fine platina wire. Another platina wire, which is movable, passes down the stem, and may be set so that the mercury shall come into contact with it at any given temperature. These platina wires are connected respectively with the poles of a galvanic battery, an electro-magnet forming part of the circuit. When the temperature of the apartment becomes so high that any increase would be objectionable, the mercury in the stem of the thermometer will have come into contact with the movable platina wire. This completes the circuit, the battery begins to act, the electro-magnet is excited, and attracts a keeper, which is connected by simple machinery with something that cuts off or diminishes the evolved heat—lessens, for example, the supply of hot air, or of air to the furnace, or turns a cock, which diminishes the quantity of hot water or steam employed as the heating agent. The instant the temperature attains its normal state, the platina wire ceases to be in contact with the mercury in the stem; battery connection is interrupted; the electro-magnet being no longer excited, the keeper separates from it, and the valve, or the regulating cock, returns to its ordinary position. In practice there may be a constant opening or closing of the valve, or regulating cock; but the action of the thermometer being very delicate, there will be no sensible variation of the temperature. To avoid the necessity of a wire movable in the stem of the thermometer, the second wire may be hermetically sealed at the point beyond which it is not intended the temperature should rise. The oxidation of the mercury by the electric sparks, and the consequent deterioration of conducting contact, is a difficulty to be feared, but one which is not, perhaps, irremediable.

YELLOW LIGHT APPLIED TO THE PRODUCTION OF DAGUERREOTYPE PICTURES.—If a prepared daguerreotype plate is exposed under a glass negative, a negative picture will be obtained, since the mercury used in developing will produce lights corresponding to the transparent portions of the negative, the shadows being formed by the bright silver surface which has been protected from the action of the light by the opaque portions of the negative. The application of the fact that yellow light destroys the effect produced by white light enables us to obtain a daguerreotype positive from a glass

negative. For this purpose, the whole of the sensitized daguerreotype plate is exposed to the action of ordinary light, and, instead of being then submitted to the mercurial vapour which would form upon it a uniform white surface, as the whole of it has been acted upon by light, it is exposed to the action of yellow light, under the glass negative. This destroys the effect previously produced by the white light in the portions corresponding to the transparent parts of the negative, which, therefore, remaining bright, on account of the mercurial developer not having any effect upon them, form the shadows and dark portions of a positive picture. It is evident from this property of yellow light that, if used incautiously by the photographer while developing, it may impair, or even destroy the distinctness and vigour of his product.

Electrical Repulsion.—The existence of both electrical attraction and repulsion has long been unanimously asserted by men of science. The existence of electrical repulsion is now questioned by M. Perrot, who brings forward strong reasons for his defection from the received dogmas of electricians. As a consequence of electrical repulsion, the electric matter must be so accumulated on the apex of a pointed body as to render it impossible for the pressure of the atmosphere, which alone prevents the escape of electricity into space, to prevent it from passing off. For the tendency of the particles to separate from each other is proportional to the square of their number on a given space, their number on a point, which is supposed infinitely small: and is, in comparison, infinitely great. If, therefore, they are kept on the point, it must be by a pressure equal to an infinite number of atmospheres. This, indeed, is strictly true only of a mathematical point, which it is impossible to form in practice: but a point as fine as can be made must require the pressure of hundreds of atmospheres to retain the electricity upon it, should electrical repulsion really exist. M. Perrot believes that it does not, and brings forward facts which seem to show that, supposing electrical repulsion, the pressure is that of so many atmospheres which would break in pieces the apparatus employed. He fixes, for instance, a pointed rod in the conductor of an electrifying machine, which is in connection with a delicate electroscope; and, having electrified the conductor, waits until the index of the electroscope becoming stationary, shows that the tendency of the electrical particles to escape, and of the atmosphere to prevent them from escaping, are *in equilibrio;* after which he takes from the conductors a spark, the length of which he notes. He then places over the pointed rod a glass tube open at both ends, and projecting a short distance beyond the apex of the rod, and takes another spark, the length of which also he notes. The second spark is far longer than the first; as long, indeed, as if there were no pointed rod fixed in the conductor. If, therefore, repulsion exists, a force equivalent to hundreds, or if the machine is very powerful, thousands of atmospheres must have been called into existence. It has been suggested by the advocates of electrical repulsion, that this force is to be found in a new repulsion exerted by the tube, and acting obliquely to the point. But such a force would burst the tube in pieces.

That no such force exists was shown by another experiment of M. Perron. He placed a thin disc of caoutchouc, or some other non-conducting substance, over the point, so that the latter projected a little beyond it. This had the same effect as the tube in causing the electricity to remain on the point; but since it was in front of, and not behind the point, it must, if electric repulsion exists, have exerted an attractive, instead of a repulsive action, equivalent to a great number of atmospheres. It has been attempted to explain the effect of the disc on the supposition that it prevents the electricity from being accumulated at the point, by interrupting conducting communication between the different parts of the pointed rod. But if such an effect were thus produced, it would follow that electricity is not transmitted by a conductor, but by the air in contact with it; and the non-conducting coating of a telegraph wire would render it incapable of transmitting electricity. M. Perron concludes, therefore, that, in reality, there is but one electrical force, namely, an attractive, which he considers sufficient to explain all electrical phenomena.

Simple Mode of Obtaining the Odoriferous Principles of Flowers, etc.—The means used hitherto for obtaining the odorous elements of flowers are troublesome, and more or less wasteful. A volatile essential oil, obtained from well-purified Pensylvanian petroleum, and termed petroleum ether, is now used very successfully for this purpose. It absorbs the odorous principle of the flowers, new quantities of which are added continually to it, until it becomes saturated. It is then separated from the odorous principle by evaporation, but little of it being lost. The fatty and other matters associated with the perfume which is left behind, may be separated from it by means of alcohol, in which they are nearly insoluble, but which dissolves the odorous principle with great facility. This method may be used for extracting any aroma, especially when contained in flowers.

Substitute for Blacklead in the Electrotype Process.—It is indispensable that, in the electrotype process, objects which consist of non-conducting substances should, in order that a metal may be deposited upon them, be coated with some good conductors. Hitherto plumbago has been employed for this purpose, but its use is attended with some serious inconveniences, and it may now be advantageously dispensed with. Instead of coating the plaster of paris, etc., with the plumbago, it is washed over, by means of a hair pencil, with a solution of acetate of copper, or—which is much better—of nitrate of silver, in alcohol, the fluid which accumulates in hollows being removed by the partially-dried pencil; and then, without being allowed to become dry, is exposed to the action of sulphuretted hydrogen. The sulphuret thus formed upon it is an excellent conductor: and when it is dry, which is very soon the case, it may be placed in the copper bath, and the copy obtained will be found entirely free from defects. An alcoholic solution of the copper or silver salt is used instead of an aqueous, as the latter would run off from the object in drops, but will not answer with stearic

acid which is dissolved by alcohol. Minute animals, and other delicate objects may be coated very readily in this way.

Substitute for Platinum in Stills, etc.—There are certain manufacturing processes which require the use of platinum vessels of large size; but as these are extremely expensive, the necessity for employing them is a very serious impediment to progress, and a great source of additional cost in production. It is now found, however, that platinized copper, the cost of which is comparatively inconsiderable, answers quite as well as solid platinum. Sulphuric acid may be evaporated in vessels made in this way, or, however concentrated, may be kept in them for weeks, without the least trace of copper being afterwards discoverable in it. Such vessels are now very frequently used in Germany.

New Application of Tannin.—Not only are new aniline dyes constantly discovered, but new and more convenient, or effective, modes of applying them are obtained. Silk and wool are easily dyed by means of them; vegetable matters, the affinities of which for colours of all kinds is much weaker, not so easily, nor so effectively. It has been discovered, however, that brilliant colours may be imparted to flax or cotton by means of the aniline dyes, if they are first impregnated with an alkaline solution of tannin. Vegetable parchment, which acts like silk or wool with reference to the aniline dyes, does not require the use of tannin. When ordinary paper is to be coloured, the tint obtained is wonderfully improved, if it is coated with albumen before being subjected to the action of tannin.

Hollow Stay-bars for Steam-boilers.—The safety often of many persons depends on the efficiency of the stay-bars of a steam-boiler. But too often their importance is not sufficiently recognized, or they are weaker or less numerous than they should be, that a little additional profit may be made by the boiler-maker. A still greater source of danger exists when they have been used, but have become so corroded as to be practically worthless: which, from their position, is very likely to be the case, and without its being probable, or perhaps possible, to discover the change they have undergone. A very simple and effective way of making them proclaim their own inefficiency is now in use on the Northern Railway of France. They are made with a small bore from end to end, and thus when one of them gives way, or is seriously corroded, the steam or water escapes through it in such a way as infallibly to attract attention. To prevent their being stopped up by dust, etc., their extremities, where not otherwise protected, are loosely closed with wood, etc., which is easily blown out by the escaping steam or water. From the smallness and position of the bore, which is exactly in the centre, the rod is scarcely at all weakened by it, but the necessary strength may be secured by a very slight augmentation of its diameter.

Miscellaneous.—*New Application of Metallic Soaps.*—Fine colouring matters, soluble in fatty matters, paraffine and similar hydrocarbons, and capable by mixture of producing any number of intermediate shades, have been discovered in the form of metallic

soaps: which are applicable also, it is probable, to the process of waterproofing. They are obtained by precipitating various metallic solutions with soda soap. In this way the salts of iron afford a brown orange stearate; those of copper a malachite green; those of nickel, an emerald green; those of chromium, a green which changes to violet; those of uranium, a bright yellow; those of cobalt, a lilac; and those of manganese, a rose red.——*Unalterable Photographs.*—The gradual and almost certain deterioration and ultimate destruction of the pictures obtained by photographic processes has ever been a source of great anxiety and regret. As, however, it is due, for the most part, to the hyposulphite or other fixing material which has been employed, and some of which has been left in the picture, there is now reason to hope that even deterioration may be prevented: since it has been found possible, not only to test the presence of this fixing material, but also, if not to remove the last traces of it, to render it harmless. For this purpose it is only necessary, after the picture has been well washed, to connect it with the poles of a galvanic battery. If any of the fixing agent is present, it will be decomposed. Should it be hyposulphite, the sulphur will appear at the negative pole, and be very perceptible, if the latter is of silver.——*Violet Subchloride of Silver.*—This compound, as being indispensable to the production of colours by means of photography, has become not only very interesting, but highly important: any simplification of the mode of obtaining it becomes, therefore, of great moment. It has been found by Mr. G. W. Simpson that it may be produced by mere exposure of a coating of ordinary chloride of silver to diffused light, which, driving off a portion of the chlorine from the the chloride, forms a sub-chloride. In the early days of the daguerreotype process, the connection between the appearance of the violet chloride on the plate, and the subsequent production of colour was noticed. But as the appearance of this peculiar tint was considered at the time merely accidental, and its connection with the production of colour was very dimly perceived, the valuable suggestion it afforded was not utilized.——*Preservation of Wood.*—Wood is naturally a very perishable substance, but it is used in enormous quantities; and in many cases, as in railway sleepers, its unsoundness is attended with great danger to human life; its preservation, or at least the prolongation of its soundness, is therefore a matter of great importance. Long since attempts in this direction were made, with more or less success: mercurial and some other metallic salts have a preservative action, but their use has been greatly limited by the great expense which it entails. Creosote and other products of the distillation of coal-tar have been found effective and convenient; but it is impossible, or at least very difficult, by the methods ordinarily used, to introduce them sufficiently deeply into the substance of the wood. This difficulty is now overcome by applying them not in the fluid, but in the vaporous state. They enter the wood with greater facility in this way, especially as its pores are expanded by the heat required for the evaporation: and they are sealed up and condensed by the subsequent cooling. The

more porous, and therefore the cheaper the wood, the more dense and more durable it becomes; and as it affords a surface capable of a good polish, it may be employed for decorative purposes.—— *Economic Mode of Evaporating Liquids.*—In evaporation, especially that of saline solution, much heat is wasted on account of the imperfect conducting power of the matters through which it must pass. This waste is prevented, in several large establishments in the north of France, by a direct application of the heat produced by combustion to the fluid that is to be evaporated, so that not only does the vapour pass off at a low temperature, heat being thus greatly economised, but that heat which is contained in the products of combustion and the atmospheric air associated with them, and which, during the ordinary mode of evaporation passes into the chimney and is lost, is utilized. In the new process, the liquid to be evaporated is, by mechanical means, scattered in the form of very minute rain through a large chamber, into which are transmitted the products of combustion—the smoke having been consumed—and the fluid, in this way exposing a very large surface to direct contact with the highly-heated gases, is evaporated with great rapidity. The resulting vapour, after leaving the chamber, is either condensed, or allowed to escape into the atmosphere. The matters contained in the residual solutions of various manufacturing processes, now considered worthless on account of the expense of evaporating in the ordinary way, may, it is probable, be utilized when this method is used.

LITERARY NOTICES.

Chemistry for Students. By Alexander W. Williamson, F.R.S., F.C.S., etc., Professor of Chemistry and Practical Chemistry in University College, London, Examiner in Chemistry at the University of London. (Oxford: at the Clarendon Press, MDCCCLXV.)—The science of chemistry has outgrown the system upon which it was recently taught in all the principal schools, and a complete revolution has been gradually effected through the influence of Charles Gerhardt, who published, in 1848, his *Introduction à l'Etude de la Chimie par le Systeme Unitaire.* Dr. Apjohn, in his well-written *Manual of the Metalloids,* observes that this system may be supposed to rest on the following propositions:—"1. That the atomic volumes of all simple substances are equal. 2. That the same is true of the atomic volumes of the compound bodies. 3. That though the atomic volume of a compound appears in some instances to be double that of an element, the ratio between the volumes of the smallest quantities of each that can exist in a separate state is mostly one of equality." The new system requires the doubling of certain atomic weights, such as those of oxygen, sulphur, and carbon, and it has led to a revision of nomenclature

with a view to express the composition of bodies, and the changes which they undergo, with greater clearness. Professor Williamson, who stands very high as a chemist, and also enjoys the reputation of being an excellent practical teacher, has just supplied a book embodying the new ideas. In his preface he tells us that it "is intended for the use of beginners in chemistry," and also of students who have made some progress in the science. In another sentence it is stated to be "intended not as a substitute for *vivâ voce* and experimental teaching, but rather as a guide and aid to students and teachers." The confusion of these statements afford indication of the kind of defect by which the work is characterized, while its merits may be equally well surmised from its author's professorial success, and from his well-known and undoubted knowledge of his subject. For beginners the book is utterly unfit; and even for teachers and advanced students it fails to supply what those who have been educated in the old system require—namely, a lucid explanation of the difference between the old philosophy and the new, and the reason why the latter is to be preferred.

The principles upon which Professor Williamson imagines he has compounded his book are those of *induction*. He says, "I describe and compare individual facts so as to lead the mind of the reader towards general principles, instead of stating the general principles first, and then proceeding to illustrate them by details." We doubt whether a good treatise capable of smoothing the path for learners could be composed upon this plan; but if that be so, Professor Williamson is not the man for the task, as the book before us shows a great want of logical perception of the manner in which such a method of instruction could be carried out. One essential to any good plan of teaching is to explain difficulties as they arise, and only to postpone such elucidations when the explanation would not be intelligible for want of some additional information that is more conveniently given at a later period. In Professor Williamson's book oxygen, hydrogen, with some of their compounds, are described in the first four chapters. Then comes a chapter on "molecules" and decompositions. Then follow sundry other chapters on nitrogen and its compounds, and then, in the thirteenth chapter, the atomic theory is explained for the first time. At page 37, where the explanation of molecule is first given, it is said to be "the smallest quantity of a compound, or an element which can exist by itself or take part in any process." At page 96 we read "molecule is the name given to the smallest cluster of atoms of any *compound* that is believed capable of existing by itself." Thus there is no mention of, or explanation of, the theory that in some simple substances the smallest quantity capable of existing or acting by itself is a *molecule*, not a single atom.

At page 95, Professor Williamson says, speaking of the red oxide of mercury, "The *atoms* of mercury are in as solid a state as those of a solid bar of the metal frozen by carbonic acid; and the atoms of oxygen which no combinations of cold and pressure has yet been able to reduce even to the liquid state, are in the mercuric oxide perfectly solid." Here surely are unphilosophical assump-

tions, based apparently upon confusion of thought. Solidity, fluidity, and the gaseous state do not involve changes in the conditions of the *atoms* of substances, but alterations in the distance, by which the atoms or the molecules are separated. If an *atom* of oxygen is fluid one minute, solid a second, and gaseous a third, it must change its size or specific gravity—which is not, we presume, what Professor Williamson intends to teach, though it is certainly what he says.

Having pointed out the faults of Professor Williamson's book, we may appear paradoxical in strongly recommending it; but we do so, not to beginners, but to teachers and advanced students, who will find a great deal of excellent matter in it, and valuable suggestions not to be met with elsewhere. The book, however, is chiefly valuable for the example which a distinguished chemist like Professor Williamson has set, in employing the new theory of chemistry, the metrical system of weights and measures, and in indicating some very excellent modes of practical teaching. For this service Professor Williamson deserves hearty thanks.

A Dictionary of Science, Literature, and Art, comprising the Definitions and Derivations of the Scientific Terms in general use, together with the History and Description of the Scientific Principles of nearly every branch of Human Knowledge. Edited by W. T. Brande, F.R.S.L. and E., of her Majesty's Mint, and the Rev. George W. Cox, M.A., late scholar of Trinity College, Oxford, assisted by Gentlemen of Eminent Literary and Scientific Acquirements. Part VIII. (Longmans.)—This thick part of Brande's Dictionary is one of the best that has appeared. The article on the microscope is somewhat meagre, but there is an excellent little treatise on music, and the astronomical papers are very good. Other papers deserve commendation; and Part VIII. will add very favourably to the reputation of the work.

SCIENTIFIC SOCIETIES.

GEOLOGICAL SOCIETY.—*March* 7, 1866.

The following communications were read:—

Documents relating to the Formation of a New Island in the neighbourhood of the Kameni Islands. By St. Vincent Lloyd, Esq., H.M. Consul at Syra, A. Delenda, Esq., Consular Agent at Santorino, and M. Décigala. Communicated by the Secretary of State for Foreign Affairs.—In these documents it was stated that on or about February 1st the sea in the neighbourhood of the Kameni Islands, in the centre of the crater forming the harbour of Santorino, began to show signs of volcanic action, and that the result

has been the formation of a new island, which has since become nearly joined to the south of the island Nea Kameni. Details of the volcanic phenomena observed up to February 7th were given in the letters from Messrs. Lloyd and Delenda; and in the impression of "La Grèce" newspaper of February 15th, M. Décigala gave an account of the further progress of the upheaval and increase of the new island, which he had named "George the First."

On the Carboniferous Slate (Devonian Rocks) of North Devon and South Ireland. By J. Beete Jukes, Esq., M.A., F.R.S., F.G.S. —Mr. Jukes gave a sketch of the geological structure of the south-west of Ireland, tracing the old red sandstone and carboniferous limestone from Wexford through Waterford into Cork, and showing that some thin beds of black shale which intervened between those groups on the east expanded westwards until they acquired a thickness of two or three thousand feet. The group then received Sir R. I. Griffith's appellation of carboniferous slate. The old red sandstone similarly expanded to the west, from a thickness of a few hundred feet in Wexford to one of several thousand feet in North Cork. Slaty cleavage, which shows itself in both these groups on the east, becomes more marked on the west, until they might both be spoken of as clay-slate formations.

West of Cork Harbour the carboniferous slate is covered in one or two places by patches of black slate, which Mr. Jukes believes to be the lower part of the Irish coal-measures, resting conformably on the carboniferous slate, with no very definite boundary between the two, as in North Devon. He looks on the carboniferous slate, especially in its upper part, as being contemporaneous with the carboniferous limestone. He believes that there is a regular consecutive series from the old red sandstone into the coal-measures, through the carboniferous limestone in one area, and through the carboniferous slate in the other.

In North Devon the author considered the dark slates and sandstones which strike from Baggy Point and Croyde Bay by Marwood and Barnstaple to Dulverton, identical with parts of the carboniferous slate of Ireland; and red and variegated sandstones and slates, rising out to the northward from underneath the grey series, identical in character with the Irish old red sandstone. On a recent visit, however, to the north coast at Lynton, Ilfracombe, and Mortehoe, he found that those beds also were identical in character with parts of the carboniferous slate, and contained some of the same fossils as are found in Ireland and in the Barnstaple district, each district having fossils not found in the others.

These beds, in the absence of any reason to suspect the contrary, would be judged to pass under that old red sandstone. Relying, however, on the conclusions formed in Ireland, Mr. Jukes believes that the central band of old red sandstone must be cut off towards the north by a great longitudinal fault, with a downthrow to the north of some 4000 feet. Mr. Jukes pointed out that this hypothesis would do away with the necessity of assigning the enormous thickness to the North Devon rocks which the ordinary hypothesis requires.

ROYAL GEOGRAPHICAL SOCIETY.—*Feb.* 26.

A paper on Exploration of the River Purûs, a tributary of the Amazons, by Mr. Chandless, was read. He found it 1866 miles long, and not, as was expected, having its head quarters in the South American river Madre de Dios. In the discussion that ensued Mr. Gerstenberg mentioned the recent discovery of a depression in the Andes of Ecuador, which would be made available for communications between the settled parts of that country and the Atlantic *viâ* the Amazons.

ZOOLOGICAL SOCIETY.—*Feb.* 27.

Dr. Gray exhibited a series of glass models of *Actiniæ*, made in Dresden, and presented to the British Museum by the Rev. R. Hudson.

NOTES AND MEMORANDA.

Photometry.—Dr. F. Zöllner has a paper in the *Astron. Nachr.*, No. 1575, in which he gives the following results of photometric observations. Comparing the sun and full moon by two methods, he obtains the following equations:—

$$\frac{\text{Sun}}{\text{Full Moon}} = 618{,}000 \text{ or } 619{,}000,$$

a determination which stands between that of Wollaston and that of Bouguer.

$$\frac{\text{Sun}}{\text{Mars}} = 6{,}994{,}000{,}000$$

$$\frac{\text{Sun}}{\text{Jupiter}} = 5{,}472{,}000{,}000.$$

$$\frac{\text{Sun}}{\text{Saturn}} = 130{,}980{,}000{,}000$$

$$\frac{\text{Sun}}{\text{Uranus}} = 8{,}486{,}000{,}000{,}000.$$

$$\frac{\text{Sun}}{\text{Neptune}} = 79{,}620{,}000{,}000{,}000.$$

He reckons the probable errors at from 1·6 to 6 per cent. in the preceding calculations.

$$\frac{\text{Sun}}{\text{Capella}} = 55{,}760{,}000{,}000.$$

The luminosity of Saturn in different positions of his ring he finds at its maximum 2·30 times that of the ball seen alone. He gives two tables of reflecting powers of terrestrial substances.

Dispersed Reflexion.		*Mirror Reflexion.*	
Fresh Snow	0.783	Quicksilver	0.648
White Paper	0.700	Speculum Metal	0.535
Whitest Sandstone	0.237	Glass	0.040
Quartz Porphyry	0.108	Obsidian	0.032
Damp Field Earth	0.079	Water	0.021
Dark Grey Syenite	0.078		

THE AERONAUTICAL SOCIETY OF GREAT BRITAIN.—This new society having secured the Duke of Argyll as its president, and a council containing the names of Messrs. Fairbairn, Glaisher, Wenham, etc., is actively engaged in enrolling members. Its objects are stated to be "to foster and develop the science of aeronautics, and incidentally to increase our knowledge of aerology." Its promoters hope to have a balloon always ready for ascension, and members may ballot for seats in the car.

THE "EXTINCTEUR" AS AN ANÆSTHETIC.—The "Extincteur" is an instrument for extinguishing fires by jets of water saturated with carbonic acid. MM. Desmartis communicate to the French Academy experiments which they have made, and they state that jets from this apparatus rapidly take away the pain from violently inflamed parts.

THE MASTODON AND THE ELEPHANT.—M. Bertrand de Lom has addressed a note to the French Academy, stating that in a bed of fossils in *Le Haute Loire* a great quantity of mammalian remains have been found, and amongst them bones of the mastodon and elephant, so situated, as to indicate that the animals were contemporaries.

STONE HAMMERS OF THE ANCIENT AMERICANS.—M. J. Marcou describes to the French Academy the discovery of these curious implements. He says in the Valleys of the Ohio and the Mississippi instruments in copper and native silver were found some time ago, and the discovery of the copper mines of Lake Superior show the source whence the metals were derived. Trenches two or three metres deep, and twenty to forty metres long, in the Company's mine, north-west of the point of Nievenau, show the extent of the ancient works. In this situation a considerable number of stone hammers have been found of an oval shape. M. Marcou obtained from the Kioway Indians a stone hammer made of quartz, with the handle attached to it by a sinew of the bison, and a band of bison's skin sewn on while fresh, so that in drying it tightly bound together the sinew and the hammer-head, only allowing the extremities to appear. A similar mode of attaching the handle has, he states, been observed in hammers of the ancient Gauls.

PROFESSOR SMITH'S ILLUMINATOR.—Prof. Smith writes to Mr. Lobb, that, as we supposed from his paper in *Silliman's Journal*, he rejected the plans adopted by Messrs. Powell and Lealand, and Smith and Beck, as not free from mist, and deficient in relief. He uses an oval mirror, perforated in the centre. Mr. Lobb has ordered one of his illuminators, made under his direction, and when it arrives in this country we shall hear more of this important invention. To view diatoms, Prof. Smith coats a glass with lamp-black, and then places on it a drop of alcohol containing diatoms, which are left by evaporation nicely spread out, and on a black ground.

THE MOUTH OF THE LOUSE.—*Annals Nat. Hist.*, No. xcix., has a translation of an important paper on this subject, by Prof. J. C. Schjödte. He controverts the notion that the objectionable animal possesses mandibles, and is able to bite; and he considers Phthiriasis as "an ancient monster, placed on the retired list" by his investigation. Examining specimens squeezed under glass appears to have been the source of prevailing errors. He finds the so-called *mandibles* to be situated *underneath* the skin, where they could not act in the manner supposed. His mode of operation is to obtain a fine specimen, and let him feed on the hand, after sharpening his appetite by a few days' abstinence. When so engaged, he cuts its head off by the sudden action of a pair of fine scissors. Placing the head under the microscope, he says, "we perceive a short dark brown haustellum, provided with hooks at its extremity, out of which an exceedingly delicate membraneous tube of variable length is hanging." Covering with thin glass causes the parts to disappear, and "leaves the old image of mandibles and palpi." He tells us that, after the animal has inserted its labium through a sweat-pore, "when the hooks (with which it is provided) get a firm hold, the first pair of setæ, the real mandibles are protruded; these are, towards their points, united by a membrane, so as to form a closed tube, from which again is extruded the

second pair of setæ, or maxillæ, which in the same manner are transformed into a tube, ending in four small lobes placed crosswise." The whole forms a sucking instrument.

Mr. Brothers' Moon Photograph.—In our last number we erroneously ascribed a lunar photograph to Mr. Rutherford, which was in reality taken by Mr. Brothers with a reflector of only five inches aperture. It is an excellent specimen of what can be done with so small an instrument.

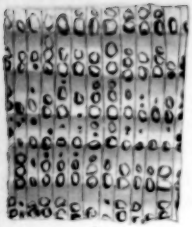
Woodwardite.—This new Cornish mineral was discovered by Mr. Talling, of Lostwithiel, and described by Prof. A. H. Church, who named it in honour of the late Dr. S. P. Woodward, at the Chemical Society, on the 1st March. It occurs in crusts one-sixth to one-third of an inch in thickness, composed of minute botryoidal aggregations of a greenish-blue colour; it is substranslucent. Hardness, 2. Specific gravity, 2·35. Woodwardite is a hydrated cupric-aluminic sulphate, and has the following composition:—$2\,Cu''\,S\,O_4$, $5\,Cu''\,H_2\,O_2$, $4\,Al'''\,H_3\,O_3 + 4\,H_2\,O$. It is an elegant object for the microscope.

Legal Use of the Microspectroscope.—The *Cambrian* newspaper, reporting the trial of Robert Cox for the Mountain Ash murder, states that Dr. Herapath, who was examined as a scientific witness, to prove that some stains were occasioned by blood, mentioned that, in addition to other tests, he had obtained characteristic bands from a solution of the suspected matter, by the use of Mr. Browning's microspectroscope.

Cause of Goitre.—M. Maumené expresses, in *Comptes Rendus*, a strong conviction that the fluorides are the agents which cause the development of goitre. He states that he administered fluoride of potassium to a dog for five months. Towards the fifth month a general swelling of the neck became apparent, more noticeable in front than behind. The dog escaped, and when found again, three years afterwards, the swelling still existed, but the symptoms were not precise enough to enable M. Gaillet, a surgeon and professor at Rheims, to form a decided opinion. M. Maumené further states that fluorides are common in the districts affected with goitre.

Chemical and Luminous Intensity.—The *Proceedings of the Royal Society*, No. 81, contain a paper by Messrs. Roscoe and Baxendell, detailing observations, from which they conclude that the effect of the atmosphere upon the highly refrangible chemical solar rays is regulated by different laws from those founded on the hypothesis of reflection by hollow water vesicles: that the ratio of the chemical intensity of direct to diffuse sunlight does not in the least correspond to the visible intensity estimated by the eye, and is not constant for a given altitude.

Discovery of an entire Mammoth.—Russian papers state that a mammoth has been discovered in the Bay of Tazovskaia, in the Government of Tomsk. Flesh, skin, and hair are reported to be well preserved. The Academy of St. Petersburg has nominated a commission to take measures for disinterring the monster, and transporting it to St. Petersburg. A native in search of some domestic animals which had strayed, perceived a great horn sticking up in the midst of a marshy plain. He went up and broke the horn, and detached a piece of skin from the head covered with red hair two and a-half inches long.



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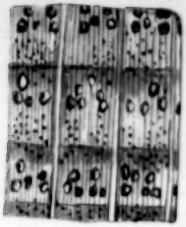

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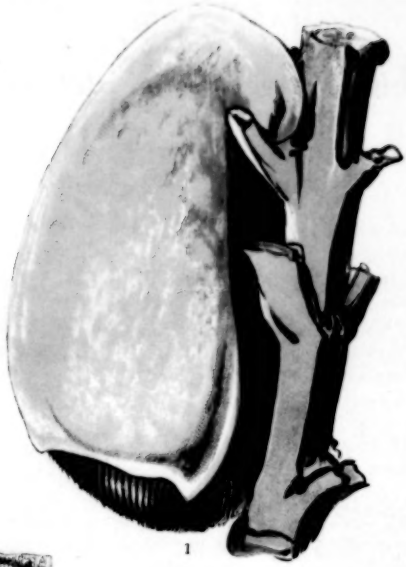

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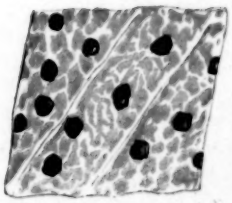

Fitch, del.

EUCALYPTUS TETRAPTERA.

Fig. 1.—Flower of Eucalyptus tetraptera, nearly nat. size.

Fig. 2.—Transverse section of the wood of Teak, magnified about 20 times.

Fig. 3.—Ditto, Oak, magnified about 20 times.

Fig. 4.—Transverse section of wood of Blue Gum, magnified about 20 times.

Fig. 5.—Magnified section of the leaf of Eucalyptus tetraptera, shewing the oil glands.